Piranha4

P4-CM-08K070-00-R

Monochrome Camera User's Manual

TELEDYNE DALSA
Everywhereyoulook™

27 June 2012
03-032-20133-01
www.teledynedalsa.com

About Teledyne Technologies and Teledyne DALSA, Inc.

Teledyne Technologies is a leading provider of sophisticated electronic subsystems, instrumentation and communication products, engineered systems, aerospace engines, and energy and power generation systems. Teledyne Technologies' operations are primarily located in the United States, the United Kingdom and Mexico. For more information, visit Teledyne Technologies' website at www.teledyne.com.

Teledyne DALSA, a Teledyne Technologies company, is an international leader in high performance digital imaging and semiconductors with approximately 1,000 employees worldwide, headquartered in Waterloo, Ontario, Canada. Established in 1980, the company designs, develops, manufactures and markets digital imaging products and solutions, in addition to providing MEMS products and services. For more information, visit Teledyne DALSA's website at www.teledynedalsa.com.

Support

For further information not included in this manual, or for information on Teledyne DALSA's extensive line of image sensing products, please contact:

North America

605 McMurray Rd
Waterloo, ON N2V 2E9
Canada

Tel: 519 886 6000
Fax: 519 886 8023

www.teledynedalsa.com

sales.americas@teledynedalsa.com
support@teledynedalsa.com

Europe

Breslauer Str. 34
D-82194 Gröbenzell (Munich)
Germany
Tel: +49 - 8142 – 46770
Fax: +49 - 8142 – 467746
www. teledynedalsa.com
sales.europe@teledynedalsa.com
support@teledynedalsa.com

Asia Pacific

Ikebukuro East 13F
3-4-3 Higashi-Ikebukuro
Toshima-ku, Tokyo 170-0013
Japan
Tel: 81 3 5960 6353
Fax: 81 3 5960 6354 (fax)
www.teledynedalsa.com
sales.asia@teledynedalsa.com
support@teledynedalsa.com

Contents

1. System Precautions and Cleaning 5
Precautions 5
Electrostatic Discharge and the CMOS Sensor 5
Protecting Against Dust, Oil, and Scratches 5
Cleaning the Sensor Window 6
2. The Piranha4 Camera 7
Camera Highlights 7
Camera Performance Specifications 8
Certifications and Compliance 9
Supported Industry Standards 9
Responsivity 10
FPN Characteristics with Temperature 10
Mechanicals 11
Camera Mounting and Heat Sink Considerations 12
3. Software and Hardware Setup 13
Recommended System Requirements 13
Setup Steps: Overview 13
1. Install and Configure Frame Grabber and GUI 13
2. Connect Camera Link and Power Cables 13
3. Establish communicating with the camera 13
4. Operate the Camera 13
Step 1. Install and configure the frame grabber, graphics card and GUI 14
Install Frame Grabber 14
Install Sapera LT and CamExpert 14
Step 2. Connect Data, Trigger, and Power Cables 14
Data Connector: Camera Link 15
Camera Link Bit Definitions 17
Camera Link cable quality and length 18
Input Signals, Camera Link 18
Output Signals, Camera Link Clocking Signals 19
Power Connector 19
LEDs 20
Step 3. Establish Communication with the Camera 20
Power on the camera 20
Connect to the frame grabber 20
Connect to the camera 20
Check LED Status 21
Software Interface 21
Using Sapera CamExpert with Piranha4 Cameras 22
CamExpert Panes 23
Review a Test Image 25
4. Camera Operation 26

Factory Settings 26
Check Camera and Sensor Information 26
Verify Temperature and Voltage 27
Saving and Restoring Camera Settings 27
Camera Link Configuration 29
TDI Stages....29
Sensitivity Mode and Pixel Readout 30
Trigger Modes....31
Exposure Controls 31
Exposure Modes in Detail 32
Set Line Rate 34
Set Exposure Time 34
Control Gain and Black Level 35
Set Image Size....35
Set Baud Rate....35
Pixel Format 36
Camera Direction Control 36
Sensor Shift Direction Example 37
Pixel Readout Direction (Mirroring Mode)....37
Binning 38
Resetting the Camera 38
Calibrating the Camera 39
Appendix A: GenICam Commands 41
Appendix B: ASCII Commands 55
EMC Declaration 65
Revision History 66
Index 67

1. System Precautions and Cleaning

Precautions

Read these precautions and this manual carefully before using the camera.

Confirm that the camera's packaging is undamaged before opening it. If the packaging is damaged please contact the related logistics personnel.

Do not open the housing of the camera. The warranty is voided if the housing is opened.

Keep the camera housing temperature in a range of 0 °C to 50 °C during operation.

Do not operate the camera in the vicinity of strong electromagnetic fields. In addition, avoid electrostatic charging, violent vibration, and excess moisture.

To clean the device, avoid electrostatic charging by using a dry, clean absorbent cotton cloth dampened with a small quantity of pure alcohol. Do not use methylated alcohol. To clean the surface of the camera housing, use a soft, dry cloth. To remove severe stains use a soft cloth dampened with a small quantity of neutral detergent and then wipe dry. Do not use volatile solvents such as benzene and thinners, as they can damage the surface finish. Further cleaning instructions are below.

Though this camera supports hot plugging, it is recommended that you power down and disconnect power to the camera before you add or replace system components.

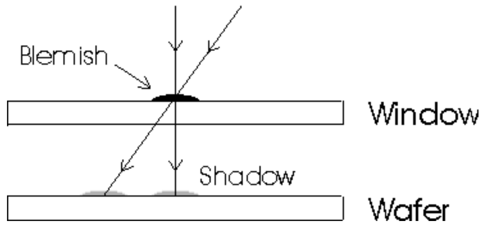
Electrostatic Discharge and the CMOS Sensor

Image sensors and the camera bodies housing are susceptible to damage from electrostatic discharge (ESD). Electrostatic charge introduced to the sensor window surface can induce charge buildup on the underside of the window that cannot be readily dissipated by the dry nitrogen gas in the sensor package cavity. The charge normally dissipates within 24 hours and the sensor returns to normal operation.

Protecting Against Dust, Oil, and Scratches

The sensor window is part of the optical path and should be handled like other optical components, with extreme care. Dust can obscure pixels, producing dark patches on the sensor response. Dust is most visible when the illumination is collimated. The dark patches shift position as the angle of illumination changes. Dust is normally not visible when the sensor is positioned at the exit port of an integrating sphere, where the illumination is diffuse. Dust can normally be removed by blowing the window surface using an ionized air gun. Oil is usually introduced during handling. Touching the surface of the window barehanded will leave oily residues. Using rubber fingercots and rubber gloves can prevent contamination. However, the friction between rubber and the window may produce electrostatic charge that may damage the sensor. To avoid ESD damage and to avoid introducing oily residues, avoid touching the sensor. Scratches diffract incident illumination. When exposed to uniform illumination, a sensor with a scratched window will normally have brighter pixels adjacent to darker pixels. The location of these pixels will change with the angle of illumination.

An important note on window blemishes:
When flat field correction is performed, window cleanliness is paramount. The figure below shows an example of what can happen if a blemish is present on the sensor window when flat field correction is performed. The blemish will cast a shadow on the wafer. FFC will compensate for this shadow by increasing the gain. Essentially FFC will create a white spot to compensate for the dark spot (shadow). As long as the angle of the incident light remains unchanged then FFC works well. However when the angle of incidence changes significantly (i.e. when a lens is added) then the shadow will shift and FFC will makes things worse by not correcting the new shadow (dark spot) and overcorrecting where the shadow used to be (white spot). While the dark spot can be potentially cleaned, the white spot is an FFC artifact that can only be corrected by another FFC calibration.



Cleaning the Sensor Window

Recommended Equipment

- Glass cleaning station with microscope within clean room.
- 3M ionized air gun 980 (http://solutions.3mcanada.ca/wps/portal/3M/en_CA/WW2/Country/)
- Ionized air flood system, foot operated.
- Swab (HUBY-340CA-003) (http://www.cleancross.net/modules/xfsection/article.php?articleid=24)
- Single drop bottle (FD-2-ESD)
- E2 (Eclipse optic cleaning system (www.photosol.com)

Procedure

- Use localized ionized air flow on to the glass during sensor cleaning.
- Blow off mobile contamination using an ionized air gun.
- Place the sensor under the microscope at a magnification of 5x to determine the location of any remaining contamination.
- Clean the contamination on the sensor using one drop of E2 on a swab.
- Wipe the swab from left to right (or right to left but only in one direction). Do this in an overlapping pattern, turning the swab after the first wipe and with each subsequent wipe. Avoid swiping back and forth with the same swab in order to ensure that particles are removed and not simply transferred to a new location on the sensor window. This procedure requires you to use multiple swabs.
- Discard the swab after both sides of the swab have been used once.
- Repeat until there is no visible contamination present.

2. The Piranha4 Camera

Camera Highlights

Based on Teledyne DALSA's unique line scan CMOS sensor architecture, the new Piranha4 8k dual line scan camera provides outstanding signal-to-noise for high speed imaging.

The P4-8k has 8k resolution with a 7 µm x 7 µm pixel size for optimized optical design. The camera delivers a max line rate of 70 kHz in a high responsivity summing mode.

Precise sensor alignment simplifies multiple camera calibration at the system level. The camera delivers a throughput of 573 MPix/ s using the Camera Link™ interface. An advanced GenICam™ compliant interface makes the camera easier to setup, control, and integrate. Programmability includes exposure control, flat field correction, and gain settings.

The Piranha4 8k camera is ideal for flat panel display, printed circuit board, solar cell, film, and large format web inspection.

Key Features

- 8192 x 2 pixels, 7.04 µm x 7.04 µm pixel pitch, 100% fill factor
- 573 MPix / s data rates
- 70 KHz line rates
- 276 DN / (nJ / cm^2) broadband @1x gain, 12 bit (dual line)
- 62 dB dynamic range

Programmability

- Adjustable digital gain and offset
- 8, 10 or 12 bit selectable output
- Adjustable integration time and line rate
- Test patterns and camera diagnostics
- Flat field calibration

Applications

- Flat-panel display inspection
- Printed circuit board inspection
- Parcel sorting
- High performance document scanning
- High throughput applications

Models

The camera is available in the following configurations:

Table 1: Camera Models Overview

Model Number	Description
P4-CM-8K070-00-R	8k resolution, 70 kHz line rate, 573 Mpix/ s throughput, Camera Link interface.

Table 2: Software

Software	Product Number / Version Number
Camera firmware	Embedded within camera
GenICam™ support (XML camera description file)	Embedded within camera
Sapera LT, including CamExpert GUI application and GenICam for Camera Link imaging driver	Version 7.20 or later

Camera Performance Specifications

Table 3: Camera Performance Specifications

Specifications	Performance
Imager Format	CMOS dual line scan
Resolution	8192 x 2 pixels
Pixel Size	7.04 µm x 7.04 µm
Pixel Fill Factor	100 %
Throughput	573 Mpix/ s
Line Rate	0 kHz minimum to 70 kHz maximum (Full), 41 kHz maximum (Medium), 20 kHz maximum (Base)
Exposure Time	11 µs minimum to 3,000 µs maximum
Bit Depth	8 bits, 10 bits, or 12 bits selectable
Connectors and Mechanicals	
Control & Data Interface	2 x Base, Medium, or Full Camera Link configurations—MDR26
Power Connector	Hirose 6-pin circular
Power Supply	+ 12 V to + 24 V DC (+11.4 V to +25.2 V maximum limits)
Power Dissipation	17 W
Size	80 mm (W) x 130 mm (H) x 57 mm (D)
Mass	< 700 g, including heat sinks (< 530 g without heat sinks)
Operating Temp	0 °C to 50 °C, front plate temperature
Optical Interface	
Lens Mount	M72 x 0.75
Sensor to Camera Front Distance	12 mm
Sensor Alignment (aligned to sides of camera)	
Flatness	50 µm
Θ y (parallelism)	0.08° or 81 µm
x	± 50 µm
y	± 50 µm
z	± 250 µm
Θ z	± 0.2°
Compliance	
Regulatory Compliance	CE and RoHS; GenICam

Operating Ranges	Performance		Notes
	Single Line	Dual Line	
Dynamic Range	62 dB	63.3 dB	
Random Noise	3.42 DN*rms	2.8 DN rms	FFC enabled
Broadband Responsivity	198 DN/ (nJ/ cm2)	276 DN/ (nJ/ cm^2)	
Gain	1x to 10x Nominal range	1x to 10x Nominal range	
DC Offset	16 DN	16 DN	FFC enabled
PRNU	<1% @50% Sat	<1% @50% Sat	
FPN	< 5 DN	< 5 DN	
SEE	20.2 nJ / cm^2	14.49 nJ / cm^2	
NEE	11.16 pJ / cm^2	12.39 pJ / cm^2	
Antiblooming	> 100 x Saturation		
Integral non-linearity	< 2% DN		

*DN = digital number

Test Conditions:

- Values measured using 12-bit, 1x gain.
- 10 kHz line rate
- Light source: broadband, quartz halogen, 3250 K with 700 nm IR cutoff filter.
- Front plate temperature: 45 C

Certifications and Compliance

Compliance
EN 55011, FCC Part 15, CISPR 11, and ICES-003 Class A Radiated Emissions Requirements
EN 55024 and EN 61326-1 Immunity to Disturbance
RoHS per EU Directive 2002/ 95/ EC and WEEE per EU Directive 2002/ 96/ EC and China Electronic Industry Standard SJ/ T11364-2006
GenICam XML Description File, Superset of the GenICam™ Standard Features Naming Convention specification V1.5, Camera Link Serial Communication: GenICam™ Generic Control Protocol (GenCP V1.0)

Supported Industry Standards

GenICam™

Piranha4 cameras are GenICam compliant. They implement a superset of the GenICam™ Standard Features Naming Convention specification V1.5.

This description takes the form of an XML device description file respecting the syntax defined by the GenApi module of the GenICam™ specification. The camera uses the GenICam™ Generic Control Protocol (GenCP V1.0) to communicate over the Camera Link serial port.

For more information see www.genicam.org.

Responsivity

The responsivity graph describes the sensor response to different wavelengths of light (excluding lens and light source characteristics).

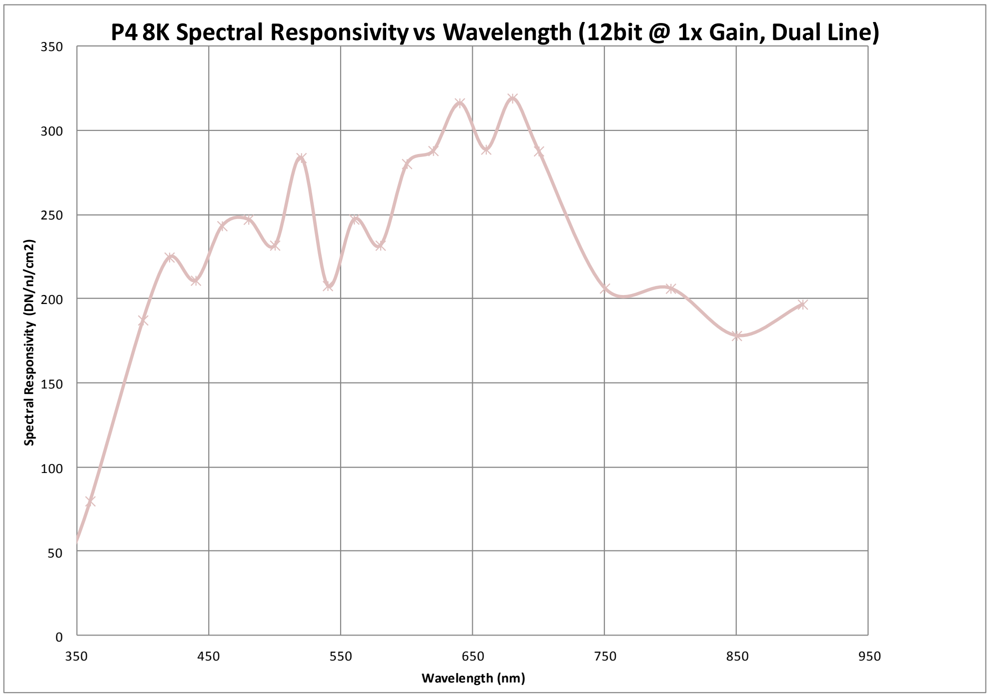


Figure 1: Spectral Responsivity vs. Wavelength (Dual Line)

FPN Characteristics with Temperature

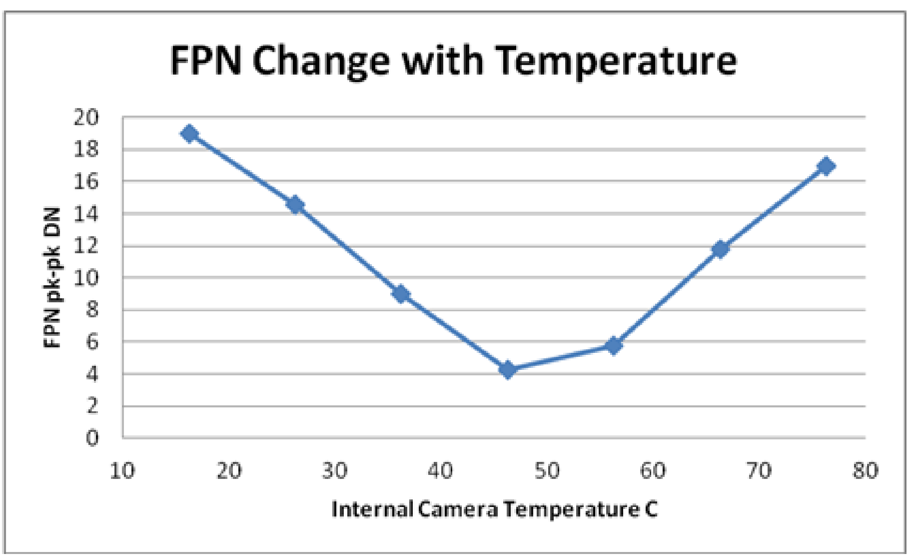


Figure 2: FPN Derating Chart

Mechanicals

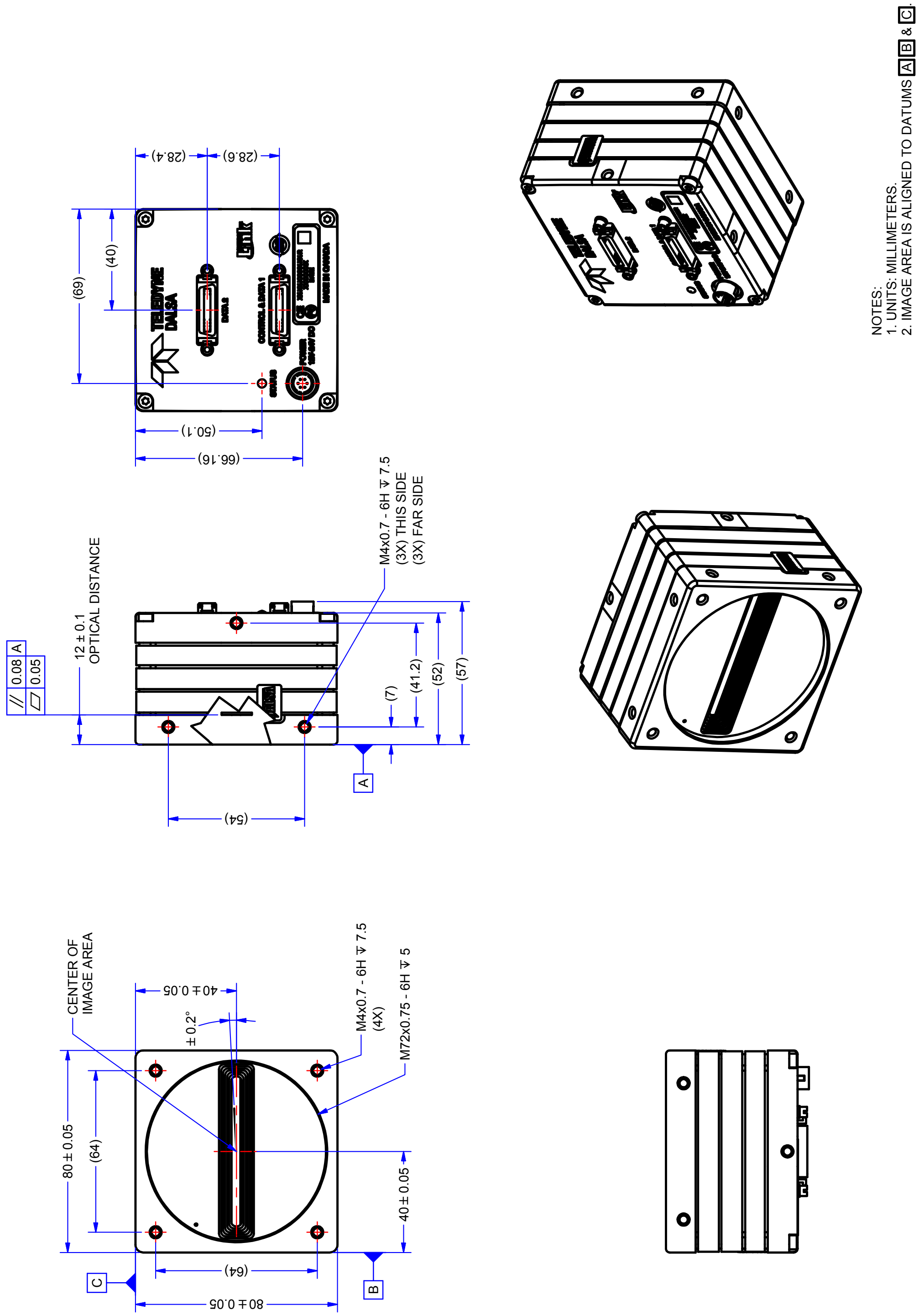


Figure 3: Camera Mechanical

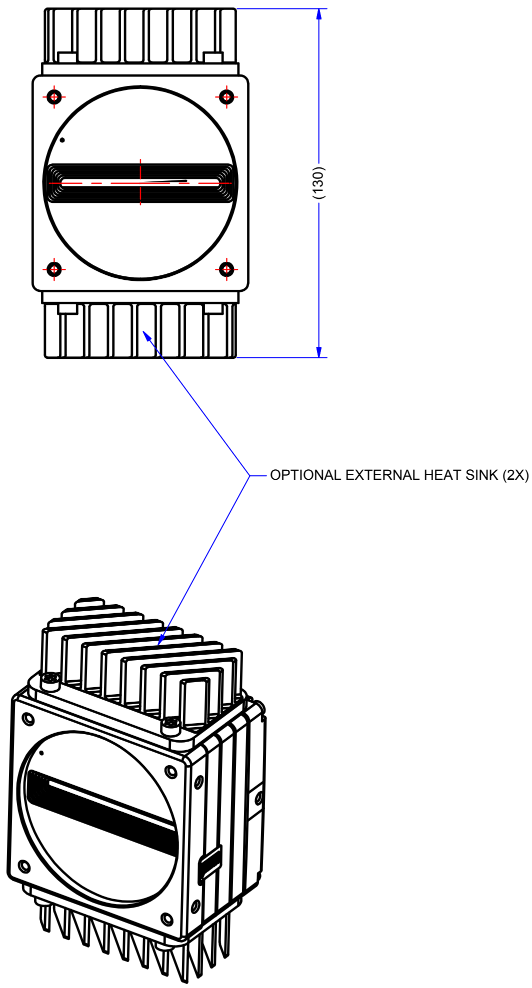


Figure 4: Camera Mechanical with External Heat Sink

Camera Mounting and Heat Sink Considerations

The Piranha4 cameras ships with two heat sinks installed and ideally positioned to allow close spacing of the cameras. These heat sinks are designed to provide adequate convection cooling when not obstructed by enclosures or mounting assemblies.

Teledyne DALSA recognises that each customer's application can be unique. In consideration, the P4 camera heat sinks have been designed in such a way that they can be repositioned on the different faces of the camera or removed entirely, depending on the mounting configuration and its heat sinking potential.

Repositioning or removal of the heat sinks must be performed with care in order to avoid temperature issues. The camera has the ability to measure its internal temperature. Use this feature to record the internal temperature of the camera when it is mounted in your system and operating under the worst case conditions. The camera will stop outputting data if its internal temperature reaches 75 °C.

3. Software and Hardware Setup

Recommended System Requirements

To achieve best system performance, the following minimum requirements are recommended:

- High bandwidth frame grabber recommended, e.g. Xcelera-CL PX4 Full Camera Link frame grabber (Part # OR-X4CO-XPF00).
- Operating system: Windows XP 32-bit.

Setup Steps: Overview

Take the following steps in order to setup and run your camera system. They are described briefly below and in more detail in the sections that follow.

1. Install and Configure Frame Grabber and GUI

If your host computer does not have a PX4 full Camera link frame grabber then you need to install one.

We recommend the Xcelera-CL PX4 Full frame grabber or equivalent, described in detail on the teledynedalsa.com site here. Follow the manufacturer's installation instructions.

A GenICam™ compliant XML device description file is embedded within the camera firmware allowing GenICam™ compliant application to know the camera's capabilities immediately after connection. Installing SaperaLT gives you access to the CamExpert GUI, a GenICam™ compliant application.

2. Connect Camera Link and Power Cables

- Connect the Camera Link cables from the camera to the computer.
- Connect a power cable from the camera to a +12 VDC to +24 VDC power supply.

3. Establish communicating with the camera

Start the GUI and establish communication with the camera. Refer to page 14 for a description on communicating with the camera.

ASCII Commands

As an alternative to the CamExpert (or equivalent) GUI, you can communicate with this camera using ASCII-based commands. A complete list of the commands and a description of how to access them can be found in the appendix: ASCII User Command Reference.

4. Operate the Camera

At this point you will be ready to start operating the camera in order to acquire images, set camera functions, and save settings.

Step 1. Install and configure the frame grabber, graphics card and GUI

Install Frame Grabber

Install a Full configuration Camera Link frame grabber according to the manufacturer's description.

We recommend the Xcelera-CL PX4 frame grabber or equivalent, described in detail on the teledynedalsa.com site here.

Install Sapera LT and CamExpert

Communicate with the camera using a Camera Link-compliant interface. We recommend you use CamExpert. CamExpert is the camera interfacing tool supported by the Sapera library and comes bundled with SaperaLT. Using CamExpert is the simplest and quickest way to send commands to and receive information from the camera.

Camera Link Control Communications
The P4 family of cameras are GenICam™ compliant. Sapera uses the GenICam™ Generic Control Protocol (GenCP V1.0) to communicate with the camera over the Camera Link serial port. When communications are first established Sapera will when connecting for the first time download the GenICam™ XML Description file. This file details how to access and control the camera.

Step 2. Connect Data, Trigger, and Power Cables

Note: the use of cables types and lengths other than those specified may result in increased emission or decreased immunity and performance of the camera.

Power
A +12V to +24V DC Hirose 6-pin

Control & Data
B Camera Link 26-pin MDR26 connectors

Status
C Diagnostic LED

Figure 5: Input and Output, Trigger, and Power Connectors

WARNING! Grounding Instructions
Static electricity can damage electronic components. It's critical that you discharge any static electrical charge by touching a grounded surface, such as the metal computer chassis, before handling the camera hardware.

Data Connector: Camera Link

The camera uses two Camera Link MDR26 cables transmitting the Camera Link Base, Medium, or Full configuration. The figure below shows the MDR26 Camera Link Connector and the tables that follow list the Camera Link Base, Medium, and Full configurations.

For detailed information on Camera Link please refer to the Camera Link Road Map available from the Knowledge Center on the Teledyne DALSA Web site:

(http://www.teledynedalsa.com/mv/knowledge/appnotes.aspx).

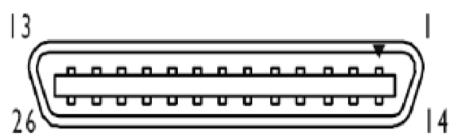


Figure 6. MDR26 Camera Link Connector

Data 2			Control / Data 1		
Camera Connector	**Right Angle Frame Grabber Connector**	**Channel Link Signal**	**Camera Connector**	**Right Angle Frame Grabber Connector**	**Channel Link Signal**
1	1	inner shield	1	1	inner shield
14	14	inner shield	14	14	inner shield
2	25	Y0-	2	25	X0-
15	12	Y0+	15	12	X0+
3	24	Y1-	3	24	X1-
16	11	Y1+	16	11	X1+
4	23	Y2-	4	23	X2-
17	10	Y2+	17	10	X2+
5	22	Yclk-	5	22	Xclk-
18	9	Yclk+	18	9	Xclk+
6	21	Y3-	6	21	X3-
19	8	Y3+	19	8	X3+
7	20	100 ohm	7	20	SerTC+
20	7	terminated	20	7	SerTC-
8	19	Z0-	8	19	SerTFG-
21	6	Z0+	21	6	SerTFG+
9	18	Z1-	9	18	CC1-
22	5	Z1+	22	5	CC1+
10	17	Z2-	10	17	CC2+
23	4	Z2+	23	4	CC2-
11	16	Zclk-	11	16	CC3-

24	3	Zclk+	24	3	CC3+
12	15	Z3-	12	15	CC4+
25	2	Z3+	25	2	CC4-
13	13	inner shield	13	13	inner shield
26	26	inner shield	26	26	inner shield

*Exterior Overshield is connected to the shells of the connectors on both ends. Unused pairs should be terminated in 100 ohms at both ends of the cable. Inner shield is connected to signal ground inside camera

Full Configuration

8 bits Camera Link Full Configuration

Connector 1: Channel link X		Connector 2: Channel link Y		Connector 3: Channel link Z	
Camera/Frame Grabber Pin	Bit Name	Camera/Frame Grabber Pin	Bit Name	Camera/Frame Grabber Pin	Bit Name
Tx0/Rx0	D0(0)	Tx0/Rx0	D3(0)	Tx0/Rx0	D6(0)
Tx1/Rx1	D0(1)	Tx1/Rx1	D3(1)	Tx1/Rx1	D6(1)
Tx2/Rx2	D0(2)	Tx2/Rx2	D3(2)	Tx2/Rx2	D6(2)
Tx3/Rx3	D0(3)	Tx3/Rx3	D3(3)	Tx3/Rx3	D6(3)
Tx4/Rx4	D0(4)	Tx4/Rx4	D3(4)	Tx4/Rx4	D6(4)
Tx5/Rx5	D0(7)	Tx5/Rx5	D3(7)	Tx5/Rx5	D6(7)
Tx6/Rx6	D0(5)	Tx6/Rx6	D3(5)	Tx6/Rx6	D6(5)
Tx7/Rx7	D1(0)	Tx7/Rx7	D4(0)	Tx7/Rx7	D7(0)
Tx8/Rx8	D1(1)	Tx8/Rx8	D4(1)	Tx8/Rx8	D7(1)
Tx9/Rx9	D1(2)	Tx9/Rx9	D4(2)	Tx9/Rx9	D7(2)
Tx10/Rx10	D1(6)	Tx10/Rx10	D4(6)	Tx10/Rx10	D7(6)
Tx11/Rx11	D1(7)	Tx11/Rx11	D4(7)	Tx11/Rx11	D7(7)
Tx12/Rx12	D1(3)	Tx12/Rx12	D4(3)	Tx12/Rx12	D7(3)
Tx13/Rx13	D1(4)	Tx13/Rx13	D4(4)	Tx13/Rx13	D7(4)
Tx14/Rx14	D1(5)	Tx14/Rx14	D4(5)	Tx14/Rx14	D7(5)
Tx15/Rx15	D2(0)	Tx15/Rx15	D5(0)	Tx15/Rx15	Not Used
Tx16/Rx16	D2(6)	Tx16/Rx16	D5(6)	Tx16/Rx16	Not Used
Tx17/Rx17	D2(7)	Tx17/Rx17	D5(7)	Tx17/Rx17	Not Used
Tx18/Rx18	D2(1)	Tx18/Rx18	D5(1)	Tx18/Rx18	Not Used
Tx19/Rx19	D2(2)	Tx19/Rx19	D5(2)	Tx19/Rx19	Not Used
Tx20/Rx20	D2(3)	Tx20/Rx20	D5(3)	Tx20/Rx20	Not Used
Tx21/Rx21	D2(4)	Tx21/Rx21	D5(4)	Tx21/Rx21	Not Used
Tx22/Rx22	D2(5)	Tx22/Rx22	D5(5)	Tx22/Rx22	Not Used
Tx23/Rx23	Not Used	Tx23/Rx23	Not Used	Tx23/Rx23	Not Used
Tx24/Rx24	LVAL	Tx24/Rx24	LVAL	Tx24/Rx24	LVAL
Tx25/Rx25	FVAL	Tx25/Rx25	FVAL	Tx25/Rx25	FVAL
Tx26/Rx26	Not Used	Tx26/Rx26	Not Used	Tx26/Rx26	Not Used
Tx27/Rx27	D0(6)	Tx27/Rx27	D3(6)	Tx27/Rx27	D6(6)

Tap 1 bits are D0(x)...Tap 8 bits are D7(x)

Camera Link Bit Definitions

BASE Configuration	T0		
Pixel Format	**Port A Bits 0 thru 7**	**Port B Bits 0 thru 7**	**Port C Bits 0 thru 7**
Mono 8	Tap 1 LSB..Bit 7 Pixels (1, 3, 5, ... 8189, 8191)	Tap 2 LSB..Bit7 Pixels (2, 4, 6, ... 8190, 8192)	xxxxxxx
Mono 12	Tap 1 LSB.. Bit 7 Pixels (1, 3, 5, ... 8189, 8191)	Tap 1 Bits 8,9,10,11 Pixels (1, 3, 5, ... 8189,8191) Tap 2 Bits 8,9,10,11 Pixels (2,4,6, ... 8190, 8192)	Tap 2 LSB..Bit 7 Pixels (2,4,6, ... 8190, 8192)

Medium Configuration	T0					
Pixel Format	**Port A Bits 0 thru 7**	**Port B Bits 0 thru 7**	**Port C Bits 0 thru 7**	**Port D Bits 0 thru 7**	**Port E Bits 0 thru 7**	**Port F Bits 0 thru 7**
Mono 8	Tap 1 LSB..Bit 7 Pixels (1, 5, 9, ... 8185, 8189)	Tap 2 LSB..Bit 7 Pixels (2, 6, 10, ... 8186, 8190)	Tap 3 LSB..Bit 7 Pixels (3, 7, 11, ... 8187, 8191)	Tap 4 LSB...Bit 7 Pixels (4, 8, 12, ... 8188, 8192)	xxxxxxxx	Xxxxxxxx
Mono 10 / Mono 12	Tap 1 LSB.. Bit 7 Pixels (1, 5, 9, ... 8187, 8191)	Tap 1 Bits 8,9,10,11 Pixels (1, 5, 9, ... 8187, 8191) Tap 2 Bits 8,9,10,11 Pixels (2, 6, 10, ... 8188, 8192)	Tap 2 LSB..Bit 7 Pixels (2, 6, 10, ... 8188, 8192)	Tap 4 LSB…Bit 7 Pixels (4, 8, 12, ... 8186, 8190)	Tap 3 LSB…Bit 7 Pixels (3, 7, 11, ... 8185, 8189)	Tap 3 Bit 8,9,10,11 Pixels (3, 7, 11, ... 8185, 8189) Tap 4 Bits 8,9,10,11 Pixels (4, 8, 12, ... 8186, 8190)

Full Configuration	T0							
Pixel Format	**Port A LSB…Bit 7**	**Port B LSB…Bit 8**	**Port C LSB…Bit 8**	**Port D LSB…Bit 8**	**Port E LSB…Bit 8**	**Port F LSB…Bit 8**	**Port G LSB…Bit 8**	**Port H LSB…Bit 8**
Mono 8	Tap 1 LSB… Bit 7 Pixels (1, 9, 17, ... 8177, 8185)	Tap 2 LSB… Bit 7 Pixels (2, 10, 18, ... 8178, 8186)	Tap 3 LSB… Bit 7 Pixels (3, 11, 19, ... 8179, 8187)	Tap 4 LSB… Bit 7 Pixels (4, 12, 20, ... 8180, 8188)	Tap 5 LSB… Bit 7 Pixels (5, 13, 21, ... 8181, 8189)	Tap 6 LSB… Bit 7 Pixels (6, 14, 22, ... 8182, 8190)	Tap 7 LSB…Bit 7 Pixels (7, 15, 23, ... 8183, 8191)	Tap 8 LSB… Bit 7 Pixels (8, 16, 24, ... 8184, 8192)

Table 4: Camera Link Bit Definitions

Signal	Configuration
CC1	EXSYNC
CC2	Spare
CC3	Direction
CC4	Spare

Table 5: Camera Control Configuration

For additional Camera Link documentation refer to the Teledyne DALSA Web site's Knowledge Center application notes.

Camera Link cable quality and length

The maximum allowable Camera Link cable length depends on the quality of the cable used and the Camera Link strobe frequency. Cable quality degrades over time as the cable is flexed. In addition, as the Camera Link strobe frequency is increased the maximum allowable cable length will decrease.

The Piranha4 cameras are capable of driving cables 10 metres or less in length. We do not guarantee good imaging performance with low quality cables of *any* length. In general, we recommend the use of high quality cables for any cable length.

Input Signals, Camera Link

The camera accepts control inputs through the Camera Link MDR26F connector. The camera ships in internal sync, and internally programmed integration.

EXSYNC (Line Readout Trigger)

Line rate can be set internally using the GenICam features. The external control signal EXSYNC is optional and enabled through the user interface. This camera uses the falling edge of EXSYNC to trigger pixel readout.

The EXSYNC signal tells the camera when to integrate and readout the image. It can be either an internally generated signal by the camera, or it can be supplied externally via the serial interface. Depending upon the mode of operation the high time of the EXSYNC signal can represent the integration period.

Note: The EXSYNC signal is measured at CC1 and will give a "true" measurement (i.e. within the measurement resolution of 25 ns) even though the camera will only trigger at a maximum of 70 KHz.

Output Signals, Camera Link Clocking Signals

These signals indicate when data is valid, allowing you to clock the data from the camera to your acquisition system. These signals are part of the Camera Link configuration and you should refer to the Camera Link Implementation Road Map, available at our Knowledge Center, for the standard location of these signals.

Clocking Signal	Indicates
LVAL (high)	Outputting valid line
DVAL	Not used
STROBE (rising edge)	Valid data
FVAL	Tied to LVAL

Power Connector

WARNING: It is extremely important that you apply the appropriate voltages to your camera. Incorrect voltages may damage the camera. Input voltage requirement: +12 VDC to +24 VDC, 2 Amps. Before connecting power to the camera, test all power supplies.

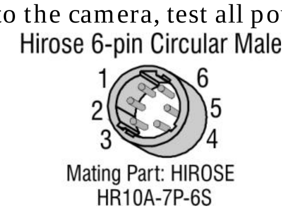


Figure 7: 6-pin Hirose Circular Male Power Plug—Power Connector

Table 6. Power Plug Pinout

Pin	Description	Pin	Description
1	+12 V to +24 V DC	4	GND
2	+12 V to +24 V DC	5	GND
3	+12 V to +24 V DC	6	GND

The camera requires a single voltage input +12 VDC to +24 VDC. The camera meets all performance specifications using standard switching power supplies, although well-regulated linear supplies provide optimum performance.

WARNING: When setting up the camera's power supplies follow these guidelines:

- Apply the appropriate voltages.
- Protect the camera with a 2 amp slow-blow fuse between the power supply and the camera.
- Do not use the shield on a multi-conductor cable for ground.
- Keep leads as short as possible in order to reduce voltage drop.
- Use high-quality supplies in order to minimize noise.

Note: If your power supply does not meet these requirements, then the camera performance specifications are not guaranteed.

LEDs

The camera is equipped with an LED on the back to display the operational status of the camera. The table below summarizes the operating states of the camera and the corresponding LED states. When more than one condition is active, the LED indicates the condition with the highest priority.

Color of Status LED	Meaning
Off	No power, or hardware malfunction.
Dark Blue	In boot-loader. Completing firmware upgrade.
Light Blue	Busy. For example, powering up or performing a calibration.
Green	Ready.
Red	Error. Check BiST register for the specific error.

Step 3. Establish Communication with the Camera

Power on the camera

Turn on the camera's power supply. You may have to wait while the camera readies itself for operation. The camera must boot fully before it will be recognized by the GUI—the LED shines green once the camera is ready.

Connect to the frame grabber

1. Start Sapera CamExpert (or equivalent Camera Link compliant interface) by double clicking the desktop icon created during the software installation.
2. CamExpert will search for installed Sapera devices. In the Devices list area on the left side, the connected frame grabber will be shown.
3. Select the frame grabber device by clicking on the name.

Connect to the camera

1. Start a new Sapera CamExpert application (or equivalent Camera Link compliant interface) by double clicking the desktop icon created during the software installation.
2. In the Devices list area on the left side, select the COM port below the CamerLink label.

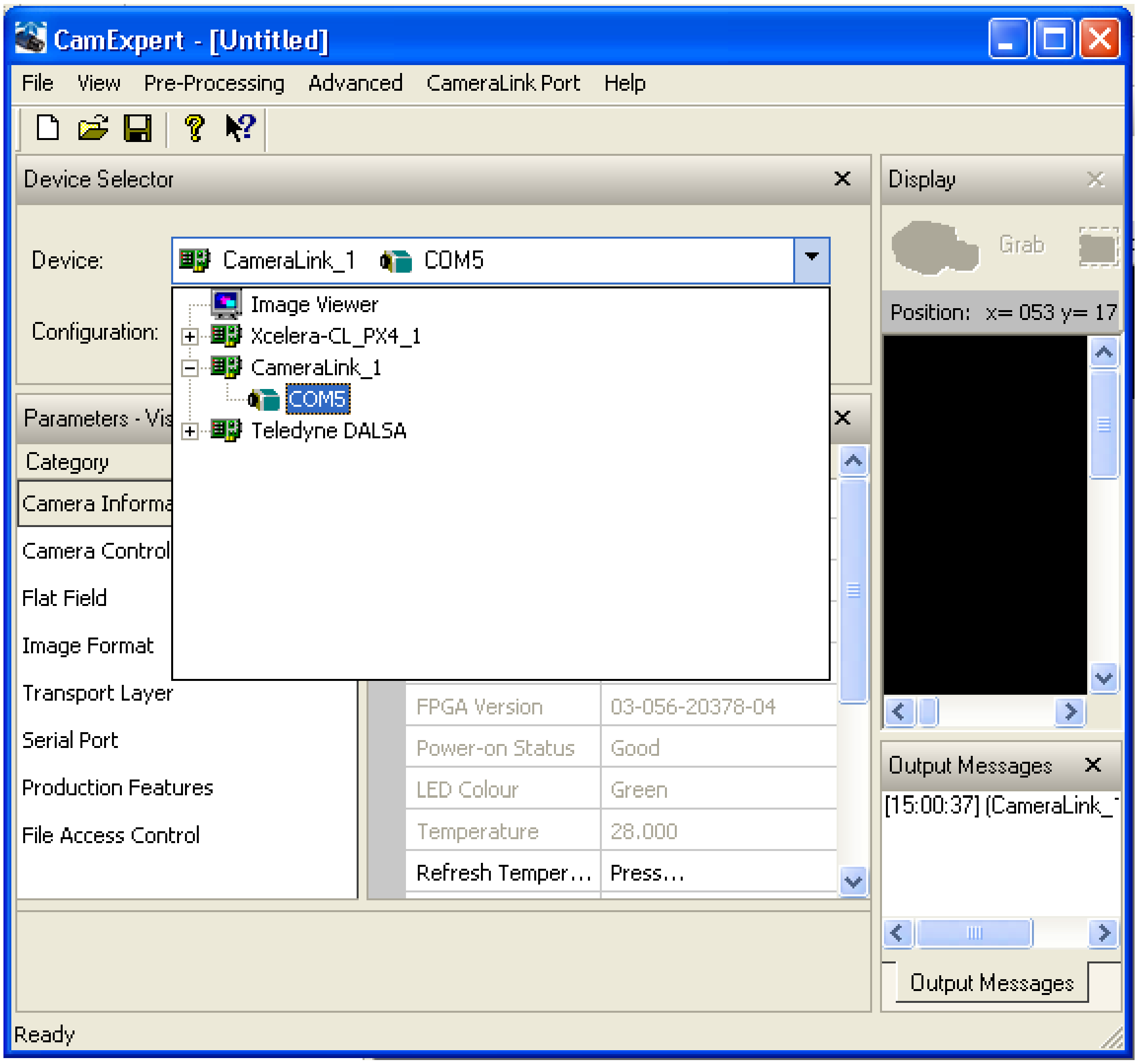


Figure 8. CamExpert GUI showing connected camera

Check LED Status

If the camera is operating correctly at this point, the diagnostic LED will shine green.

Software Interface

All the camera features can be controlled through the CamExpert interface. For example, under the Camera Control menu in the camera window you can control the line rate and exposure times.

Note: the camera uses two CamExpert windows to send commands and display the results. One window controls the camera and the other is used for image acquisition and display.

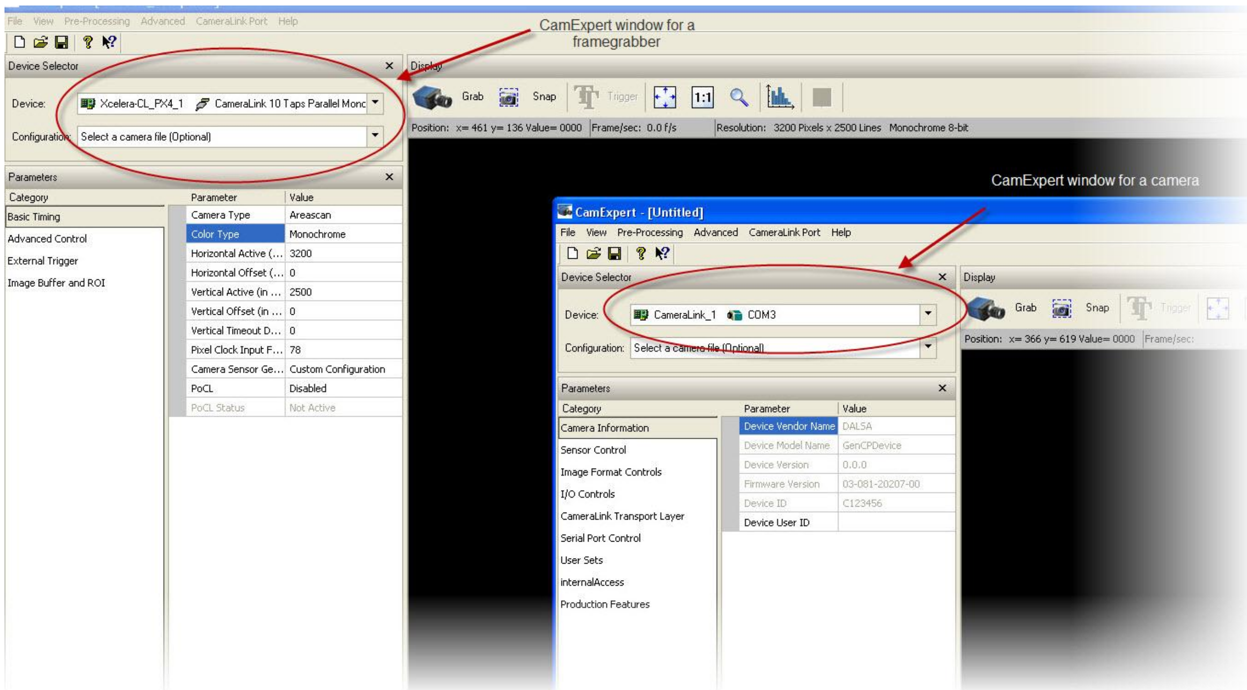


Figure 9. Two CamExpert window shown. One connected to the frame grabber and one to the camera.

At this point your host and camera system should be setup and you can verify the camera's operation by retrieving a test pattern and setting the camera's trigger and exposure time.

Note that within the CamExpert window that controls the camera, the image display and associated buttons such as Grab and Snap are inactive and have no function.

Using Sapera CamExpert with Piranha4 Cameras

CamExpert is the camera interfacing tool supported by the Sapera library. When used with a Piranha4 camera, CamExpert allows a user to test all camera operating modes. Additionally CamExpert saves the camera user settings configuration to the camera or saves multiple configurations as individual camera parameter files on the host system (**.ccf*). CamExpert can also be used to upgrade the camera's software.

An important component of CamExpert is its live acquisition display window which allows immediate verification of timing or control parameters without the need to run a separate acquisition program.

For context sensitive help, click on the  button then click on a camera configuration parameter. A short description of the configuration parameter will be shown in a popup. Click on the  button to open the help file for more descriptive information on CamExpert.

The central section of CamExpert provides access to the camera features and parameters. Note: The availability of the features is dependent on the CamExpert user setting.

CamExpert Panes

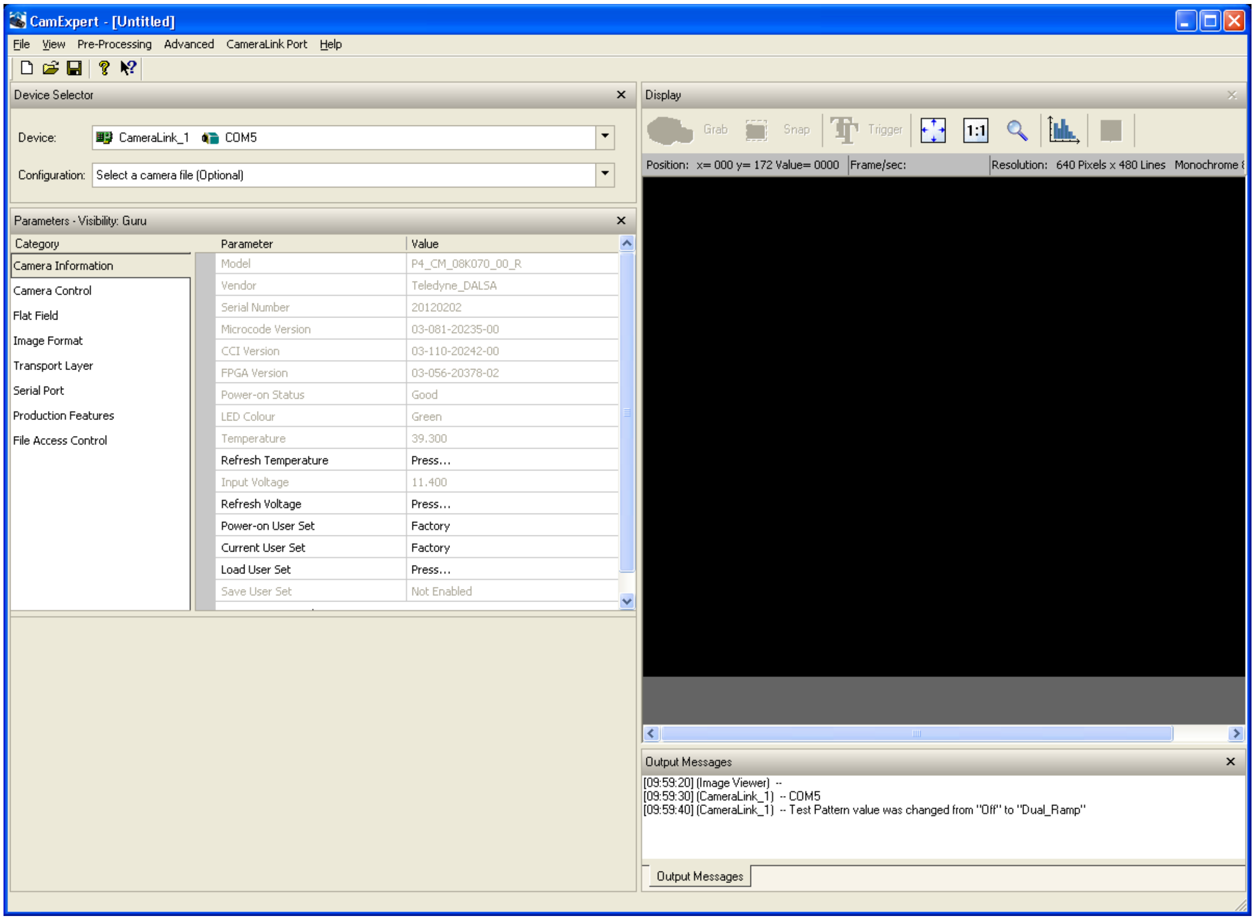


Figure 10. CamExpert's Camera Control Window

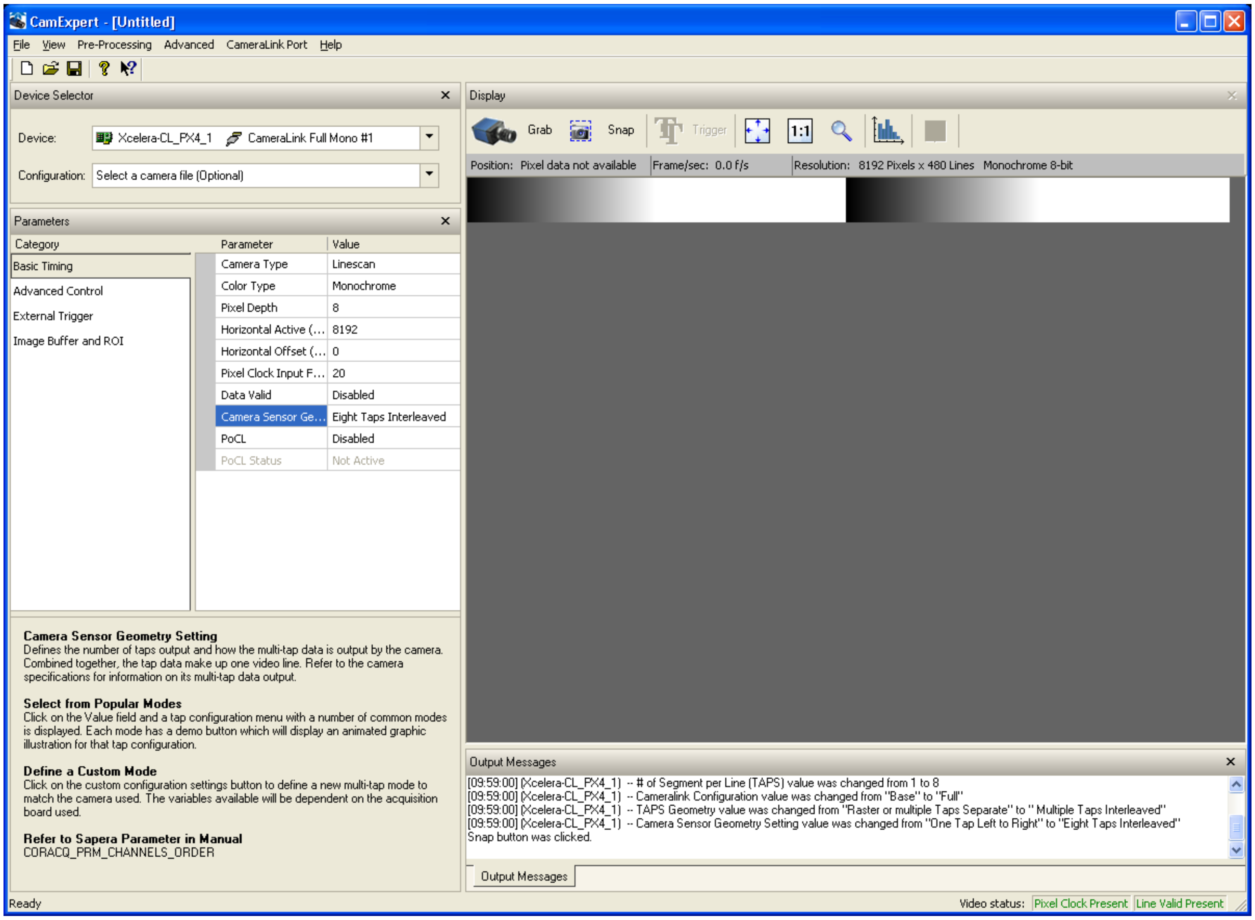
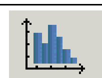


Figure 11. CamExpert's Image Acquisition Window

The CamExpert application uses panes to simplify choosing and configuring camera files or acquisition parameters for the installed device.

- **Device Selector pane:** View and select from any installed Sapera acquisition device. Once a device is selected CamExpert will only present acquisition parameters applicable to that device. Optionally select a camera file included with the Sapera installation or saved by the user.
- **Parameters pane:** Allows viewing or changing all acquisition parameters supported by the acquisition device. CamExpert displays parameters only if those parameters are supported by the installed device. This avoids confusion by eliminating parameter choices when they do not apply to the hardware in use.
- **Display pane:** Provides a live or single frame acquisition display. Frame buffer parameters are shown in an information bar above the image window.
- **Control Buttons:** The Display pane includes CamExpert control buttons. These are:

	**Acquisition control button:** Click once to start live grab, click again to stop.
	**Single frame grab:** Click to acquire one frame from device.
	**Trigger button:** With the I/ O control parameters set to Trigger Enabled, click to send a single trigger command.
	**CamExpert display controls:** (these do not modify the frame buffer data) Stretch image to fit, set image display to original size, or zoom the image to any size and ratio.
	**Histogram / Profile tool:** Select to view a histogram or line/ column profile during live acquisition or in a still image.

- **Output Message pane:** Displays messages from CamExpert or the device driver.

Review a Test Image

The camera is now ready to retrieve a test pattern. Select **Image Format Control** > **Test Pattern** and choose one of the following available test images.

1. Off: Sensor Video
2. Ramp

4. A5: 4 pixels repeating*

5. Each Tap Fixed*

6. All_1365*

7. All_1*

*12-bit, single line. low sensitivity.

At this point you are ready to start operating the camera in order to acquire images, set camera functions, and save settings.

4. Camera Operation

Factory Settings

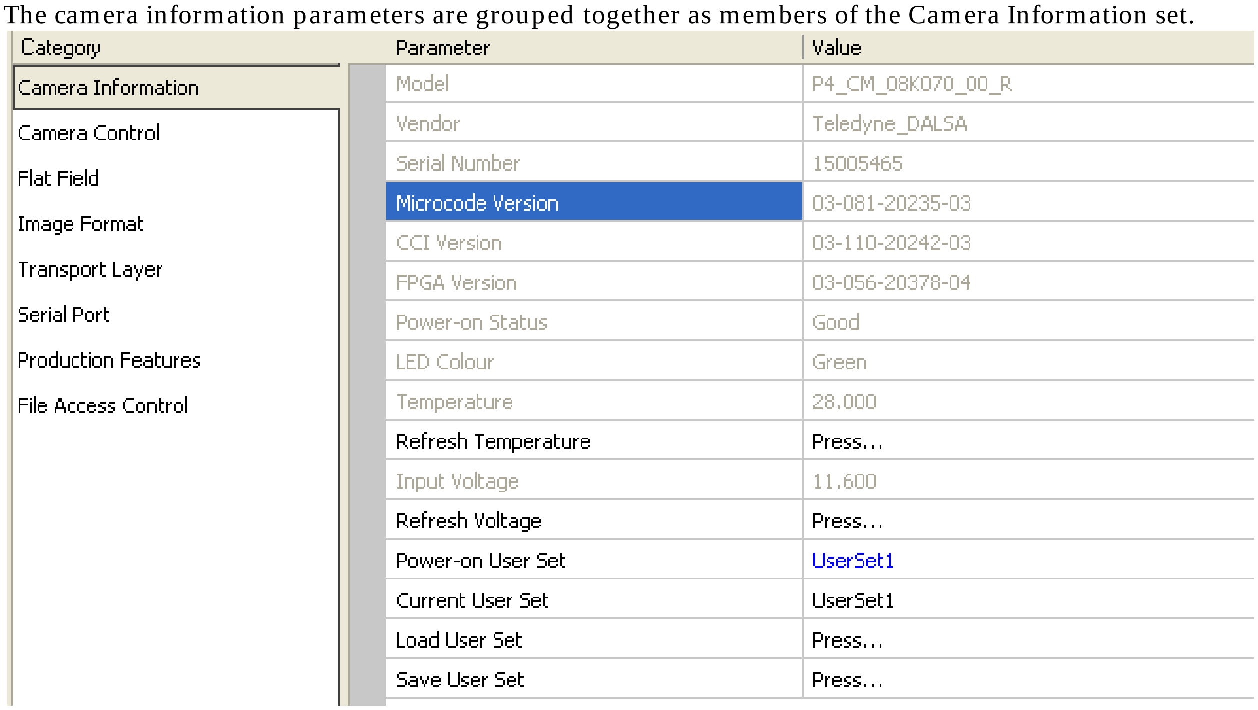
The camera ships and powers up for the first time with the following factory settings:

- Camera Link Full, 8 bit pixels
- Internal trigger, line rate 10 kHz
- Internal exposure control, exposure time 50 µs
- 2 stage TDI
- 1x horizontal and vertical binning
- Flat field enabled, all pixel coefficients set to 1x
- Offset 0, Gain 1x

Check Camera and Sensor Information

Camera and sensor information can be retrieved via a controlling application—for example, the CamExpert GUI shown in the following examples. Parameters such as camera model, firmware version, sensor characteristics, etc. are read to uniquely identify the connected device.

The camera information parameters are grouped together as members of the Camera Information set.



Verify Temperature and Voltage

To determine the voltage and temperature at the camera, use the **Refresh Voltage and Refresh Temperature** features found in the **Camera Information** set.

The temperature returned is the internal temperature in degrees Celsius. For proper operation, this value should not exceed 75 °C. If the camera exceeds the designated temperature it will stop imaging and the LED will turn red. Once you have diagnosed and remedied the issue use the **reset camera** function.

The voltage displayed is the camera's input voltage. Note that the voltage measurement feature of the camera provides only approximate results (typically within 10% and dependent on the voltage drop in the cable). The measurement should not be used to set the applied voltage to the camera, but only used as a test to isolate gross problems with the supply voltage.

Saving and Restoring Camera Settings

The parameters used to select, load and save user sets are grouped together under the Camera Information set of features. There are 8 user sets available and one factory set.

Camera Information	
Parameter	**Choices**
User Set Default Selector	Select the camera parameters to load when the camera is reset or powered up as the Factory set, or as User Set 1 to 8. Selecting the set from the list automatically saves it as the default set.
User Set Selector	Select the Factory or User set to Save or Load. -Factory Set -User Set 1 to 8.
User Set Load	Load the set specified by User Set Selector to the camera and make it the active / current set.
User Set Save	Save the current set as selected user set.

Description of the Camera Settings

The camera operates in one of three settings:

1. Current session.
2. User setting.
3. Factory setting (read-only).
4. Default setting.

The current settings can be saved (thereby becoming the user setting) using the User Set Save parameter. A previously saved user setting (User Set 1 to 8) or the factory settings can be restored using the User Set Selector and User Set Load parameters.

Either the Factory or one of the User settings can be saved as the Default Setting by selecting the set in the User Set Default Selector. The chosen set automatically saves as the default setting and is the set loaded when the camera is reset or powered up.

The relationship between these three settings is illustrated in Figure 12. Relationship between the Camera Settings:

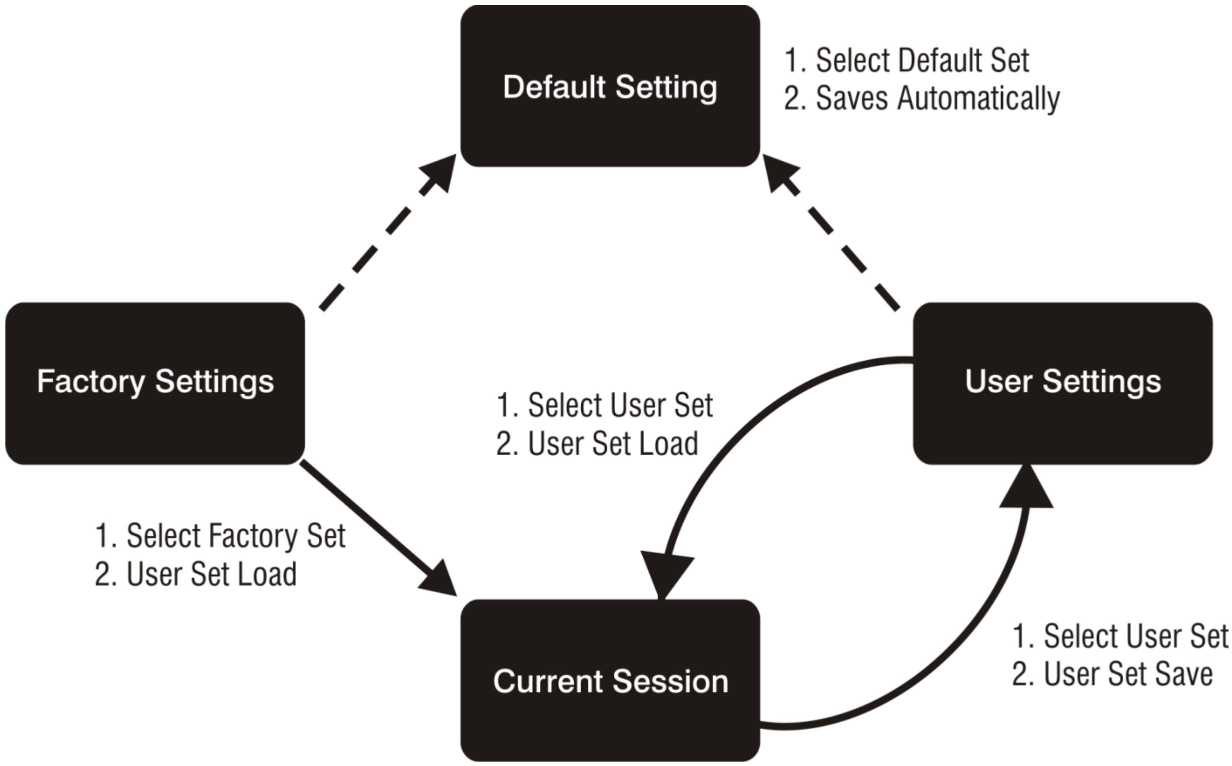


Figure 12. Relationship between the Camera Settings

Active Settings for Current Session

The active setting for the current session is the set of configurations that are operating while the camera is currently running, including all unsaved changes you have made to the settings before saving them.

These active settings are stored in the camera's *volatile* memory and will be lost and cannot be restored if the camera resets or if the camera is powered down or loses power.

To save these settings for reuse the next time you power up or reset the camera, or to protect against losing them in the case of power loss, you must save the current settings using the **User Set Save** parameter. Once saved, the current settings become the selected **User Set**.

User Setting

The user setting is the saved set of camera configurations that you can customize, resave, and restore. By default the user settings are shipped with the same settings as the factory set.

The command **User Set Save** saves the current settings to non-volatile memory as a **User Set**. The camera automatically restores the last saved user settings when it powers up.

To restore the last saved user settings, select the **User Set** parameter you want to restore and then select the **User Set Load** parameter.

Factory Settings

The factory setting is the camera settings that were shipped with the camera and which loaded during the camera's first power-up. To load or restore the original factory settings, at any time, select the **Factory Setting** parameter and then select the **User Set Load** parameter.

Note: By default, the user settings are set to the factory settings.

Default Setting

Either the Factory or one of the User settings can be used as the Default Setting by selecting the set in the User Set Default Selector. The chosen set automatically becomes the default setting and is the set loaded when the camera is reset of powered up.

Camera Link Configuration

Name	Taps	SPF*	Cables
Base	2	8, 10, 12	1
Medium	4	8, 10, 12	2
Full	8	8	2

*Set Pixel Format (number of bits per pixel)

TDI Stages

You have the option to set the TDI stages as either a single line (1: low sensitivity mode) or as the sum of a pair of lines (2: high sensitivity mode).

TDI Stages and Direction Control

If the camera's direction is set to reverse, then the TDI stage is locked to TDI stage 2. While operating in TDI stage 1 the direction control is not available and will be greyed out, the camera must be operating with internal direction control.

TDI Stage 2 Vs. Vertical Binning 2

TDI delays the line sum one line-time so that each row images the same area. Whereas with vertical binning 2, which can also be referred to as "tall pixel mode," the rows image adjacent areas and are summed without separation delay. This action combined with horizontal binning 2 results in a big pixel that has half the resolution but is four times as responsive.

Sensitivity Mode and Pixel Readout

The camera has the option to operate in either high sensitivity (dual line) or low sensitivity (single line) modes.

When in high sensitivity mode, the camera uses both line scan sensors and as a result the responsivity increases (40%). When in low sensitivity mode, the camera uses the bottom sensor only. The internal gain is 1.4x greater for low sensitivity mode vs. high sensitivity mode.

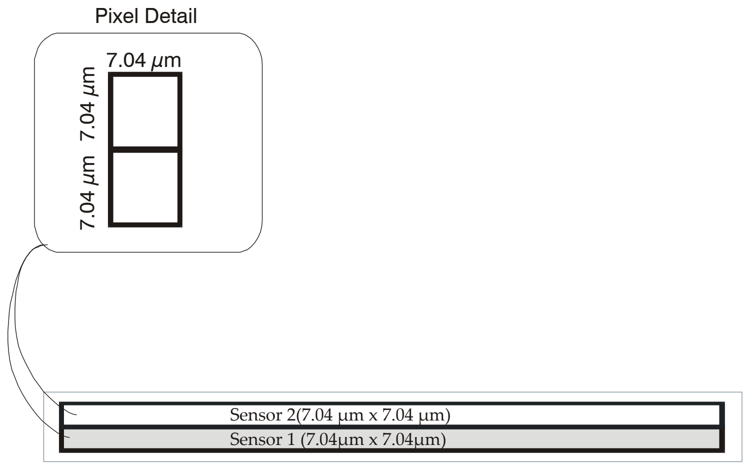


Figure 13: High Sensitivity Mode

In high sensitivity mode, the camera uses a 7.04 µm x 7.04 µm pixel and captures the same image twice, resulting in a brighter image.

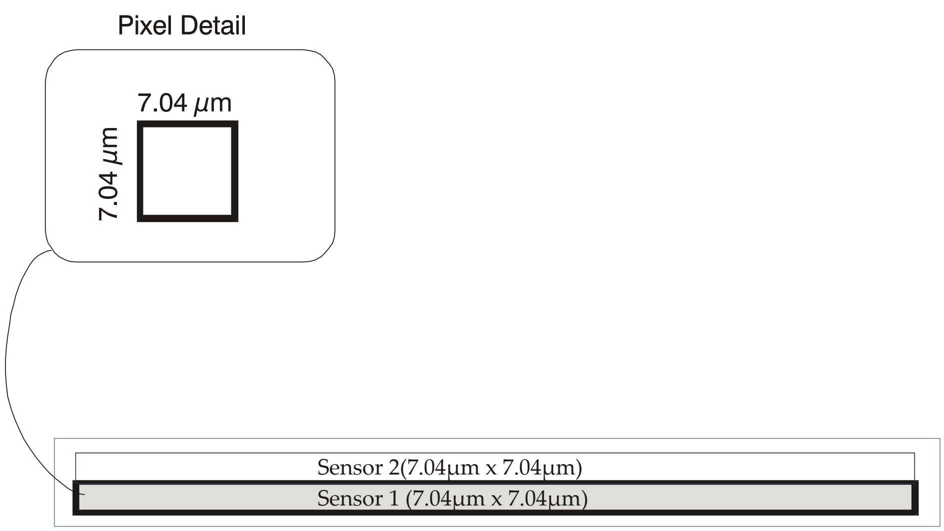


Figure 14: Low Sensitivity Mode

In low sensitivity mode, the camera uses a 7.04 µm x 7.04 µm pixel and captures the image using one sensor (Sensor 1).

Trigger Modes

The camera's image exposures are initiated by a trigger event. The trigger event is either a programmable internal signal used in free running mode, an external input used for synchronizing exposures to external triggers, or a programmed function call message by the controlling computer. These triggering modes are described below.

- **Internal trigger (trigger disabled):** The camera free-running mode has a programmable internal timer for line rate and a programmable exposure period.
- **External trigger (trigger enabled):** Exposures are controlled by an external trigger signal. The external trigger signal is the Camera Link control line CC1.

Exposure Controls

The Exposure Control modes define how and when the camera will capture an image—the integration period. The integration period is the amount of time the camera's sensor is exposed to incoming light before the captured image is transmitted to the controlling computer.

- Exposure control is defined as the start of exposure and exposure duration.
- The start of exposure can be an internal timer signal (free-running mode) or an external trigger signal.
- The exposure duration can be programmable (such as the case of an internal timer) or controlled by the external trigger pulse width.

The camera can grab images in one of three ways. You determine the three imaging modes using a combination of the Exposure Mode parameters (including I/O parameters), Exposure Time and Line Rate parameters.

Description	Line Rate	Exposure Time	Trigger Source (Sync)
Internal line rate and exposure time	Internal, programmable	Internal programmable	Internal
External line rate and exposure time	Controlled by EXSYNC pulse	External (EXSYNC)	External
EXSYNC pulse controlling the line rate. Programmed exposure time.	Controlled by EXSYNC pulse	Internal programmable	External

Figure 15. Exposure controls

The parameters used to select the imaging modes—trigger sources (sync), exposure time, and line rate—are grouped together as the Camera Controls.

Camera Controls	
Parameter	**Description**
Line Rate (in Hz)	Camera line rate in Hz. Only available when the start line trigger parameter is disabled (Trigger Mode off).
Exposure Mode	Set the operation mode for the camera's exposure. Trigger Width or Timed. Trigger Width is only available when Trigger Mode is enabled.
	Trigger Width Uses the width of the current line trigger signal pulse to control the exposure duration.

	Timed The exposure duration time is set using the Exposure Time feature and the exposure starts with the Line Start event.
Exposure Time	Sets the exposure time (in microseconds). Exposure Mode feature must be set to Timed

Exposure Modes in Detail

1. Internally Programmable Line rate and Internally Programmable Exposure Time (Default)

Line rate is the dominant factor when adjusting the line rate or exposure time. When setting the line rate, exposure time will decrease, if necessary, to accommodate the new line rate. When adjusting the exposure time the range is limited by the line rate.

Note: The camera will not set line periods shorter than the readout period.

GenICam parameters to set:
I / O Controls > Trigger Mode > Off

2. External Line Rate and External Exposure Time (Trigger Width)

In this mode, EXSYNC sets both the line period and the exposure time. The rising edge of EXSYNC marks the beginning of the exposure and the falling edge initiates readout. Note:

$$\text{maximum line rate} = \frac{1}{(\text{exposure time} + \text{low time*})}$$

*Exposure time must be greater than 6 μs and low time greater than 1,500 ns

GenICam parameters to set:
- **I / O Controls > Trigger Mode > On**
- **Camera Control > Exposure Mode > Trigger Width**

Warning! When running external line rate and external exposure time, the line rate must not exceed 1 / (exposure time + 1,500 ns). Under these conditions the exposure time will become indeterminate and result in image artefacts. This is not the case when running internal exposure control.

3. External Line Rate, Programmable Exposure Time

In this mode, the line rate is set externally with the falling edge of EXSYNC generating the rising edge of a programmable exposure time.

GenICam parameters to set:
- **I / O Controls > Trigger Mode > On**
- **Camera Control > Exposure Mode > Timed**

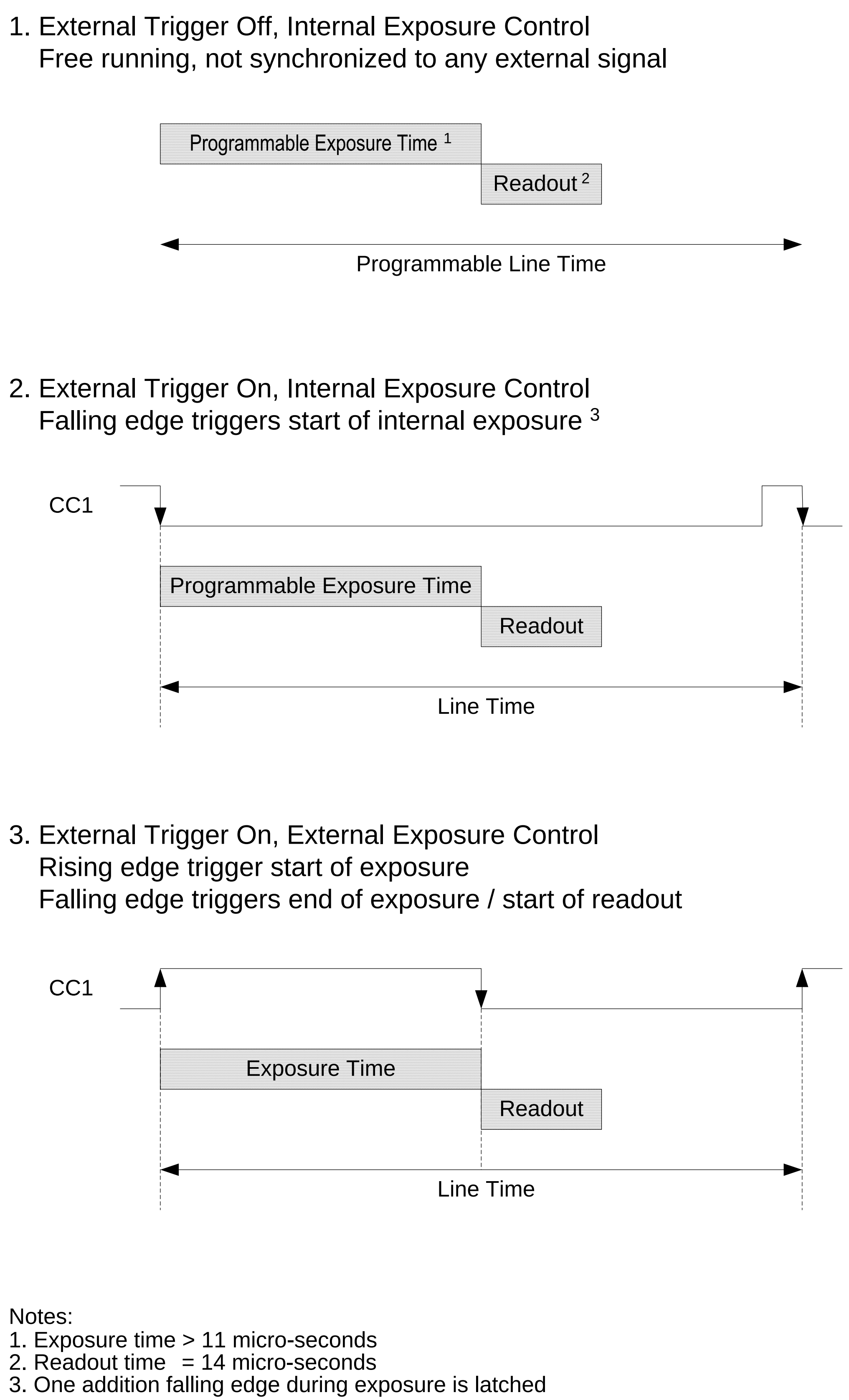


Figure 16. Exposure Modes

Set Line Rate

To set the camera's line rate use the line rate parameter, part of the Camera Controls set. This feature can only be used when the camera is in Internal mode—that is, when the start line trigger is disabled (Trigger Mode Off).

$$\text{maximum line rate} = \frac{1}{(\text{exposure time} + \text{low time*})}$$

*Exposure time must be greater than 6 μs and low time greater than 1,500 ns

Note: A line rate < 1 / (Exposure time + 1,500 ns) will return an error ("Invalid Parameter") if this condition is not met. You must adjust these two parameters in the correct sequence to maintain this condition.

If the external line rate exceeds 70 kHz the camera will continue to output data at its maximum line rate of 70 kHz. Though no image artefacts associated with over-speed will occur, you may notice that under over-speed conditions the image will appear compressed and the apparent distance travelled will be reduced.

Camera Control	
Parameter	**Description**
Line Rate (in Hz)	Camera line rate in a range from 1 Hz to 70 KHz. This feature is only available when the camera is in Internal Mode—line trigger is disabled (Trigger Mode off).

Line Rates	
Camera Link Configuration	**Maximum Line Rate**
Base	20 kHz (Up to 41 kHz with the use of horizontal binning at 2x)
Medium	41 kHz
Full	70 kHz

Set Exposure Time

To set the camera's exposure time, use the **Exposure Time** parameter—a member of the Camera Controls set. This feature is only available when the **Exposure Mode** parameter is set to **Timed**. The allowable exposure range is from 11 µs to 3,000 µs, dependent on the value of the internal line rate.

GenICam parameters:
Camera Controls > Exposure Time (Timed Exposure Mode) > 11 µs to 3,000 µs.

Control Gain and Black Level

The cameras provide gain and black level adjustments in the digital domain for the CMOS sensor. The gain and black level controls can make small compensations to the acquisition in situations where lighting varies and the lens iris cannot be easily adjusted. The user can evaluate gain and black level by using CamExpert.

The parameters that control gain and black level are grouped together in the Camera Controls set.

Camera Controls	
Black Level	Apply a digital addition after an FPN correction: ± 1/ 8 of available range. For example in 12-bit mode the available range is -512 to +511.
Gain	Set the gain as an amplification factor applied to the video signal across all pixels: 1x to 10x.

Set Image Size

To set the height of the image, and therefore the number of lines to scan, use the parameters grouped under the Image Format Control set.

Image Format Control	
Control the size of the transmitted image	
Width	Width of the image. Read only.
Height	Height of the image in lines. Read only.
Pixel Format	Mono 8, Mono 10, or Mono 12 bit depth to Camera Link.
Test Image Selector	Select an internal test image: Off Ramp A5 Each Tap Fixed All 1365 All 1

Set Baud Rate

The baud rate sets the speed (in bits per second—bps) of the serial communication port and is available as part of the Serial Port Control parameters.

Serial Port Control		
Action	**Parameter**	**Options**
Control the baud rate used by the camera's serial port	Baud Rate	9600 (factory default) 19200 57600 115200 230400*

		460800* 921600* Note: During connection CamExpert automatically sets the camera to maximum allowable baud. *Your system requires a Px8 frame grabber to achieve these baud rates.
Number of bits per character used in the serial port	Data Size	8
Parity of the serial port	Parity	None
Number of stop bits per character used in the serial port	Number of Stop Bits	1

Pixel Format

Use the Pixel Format feature, found in the **Image Format Control** set, to select the format of the pixel to use during image acquisition, as either Mono 8, Mono 10, or Mono 12 bit depth.

GigE Vision Input Controls

Image Format Control	
Parameter	**Description**
Pixel Format	Mono 8* Mono 10 Mono 12 *Only available format for Full CameraLink configuration.

Camera Direction Control

Found in the **Camera Control** > **Direction Control** set of features. Note: This feature is only available when in high sensitivity mode only (TDI stage 2).

Note: the **Sensor Shift** features are not available when the camera is in low or tall pixel sensitivity modes.

GigE Vision Input Controls

Camera Control > Direction Control	
Parameter	**Description**
Scan Direction Source	When in TDI stages 2, this command lets you select the **Internal** or **external direction control**. Use this feature to accommodate object direction change on a web and to mount the camera "upside down."
Scan Direction	Read the current direction.

Sensor Shift Direction Example

When in high sensitivity mode, you can select either forward or reverse sensor shift direction. Selectable direction accommodates object direction change on a web and allows you to mount the camera "upside down".

Note that the example here assumes the use of a lens (which inverts the image).

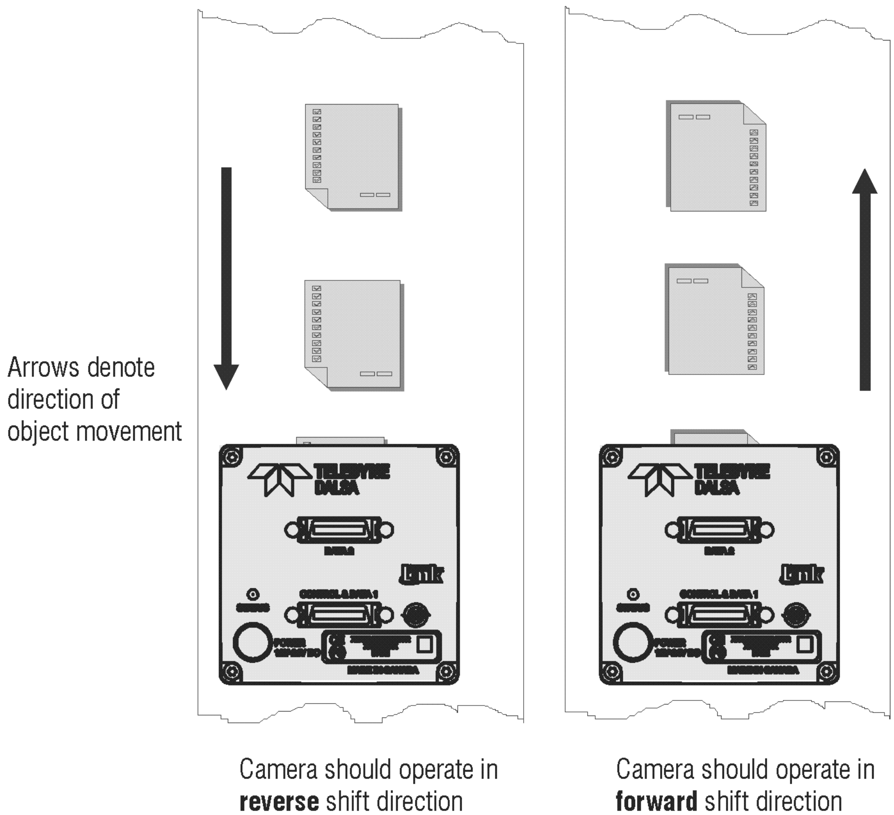


Figure 17: Object Movement and Camera Direction Example using an Lens

Pixel Readout Direction (Mirroring Mode)

Set the tap readout from left to right or from right to left. This feature is especially useful if you want to mount the camera "upside down."

GigE Vision Input Controls

Image Format Control	
Parameter	**Description**
ReverseX	Off: All pixels are read out from left to right. On: All pixels are read out from right to left.

Binning

Binning is the combining of two or more image sensor pixels to form a new combined pixel. A binned image using the same exposure settings as a non-binned image will show an improved signal-to-noise ratio, reduced scanning times (due to lower spatial resolution) and save as a smaller image file size compared with a non-binned image, at the expense of lower image resolution.

In 2 x 2 binning, 4 physical pixels on the sensor are combined into one image pixel. This operating mode is ideal for applications that require faster acquisition and processing times and require greater signal collection.

For this camera, the default binning value is 1 x 1,

The **Binning Vertical** and **Binning Horizontal** features in the **Image Format Control** set represents the number of horizontal pixels that will be combined (added) together.

Note: Compared to running the camera in high-sensitivity mode, running the camera in 2 x 2 binning mode will result in 4x responsivity, not 2x.

GigE Vision Input Controls

Image Format Control	
Parameter	**Description**
Binning Vertical	This feature represents the number of vertical photo-sensitive cells that must be combined (added) together: 2. Note: TDI stages must be set to 1 before vertical binning can be changed to 2x.
Binning Horizontal	This feature represents the number of horizontal photo-sensitive cells that must be combined (added) together.

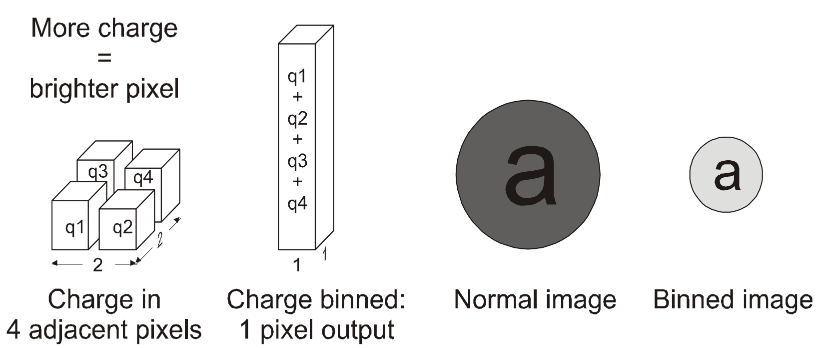


Figure 18: 2x2 Binning in Area Mode

Resetting the Camera

The feature **Camera Reset**, part of the **Transport Layer** set, resets the camera. The camera resets with the default settings, including a baud rate of 9600.

GigE Vision Input Controls

Transport Layer	
Parameter	**Description**
Camera Reset	Resets the camera and puts in the default settings, including a 9600 baud rate.

Calibrating the Camera

Important Note: to ensure best results, the conditions under which you calibrate the camera (e.g. temperature and illumination) should be as close to the actual operating conditions as possible. .

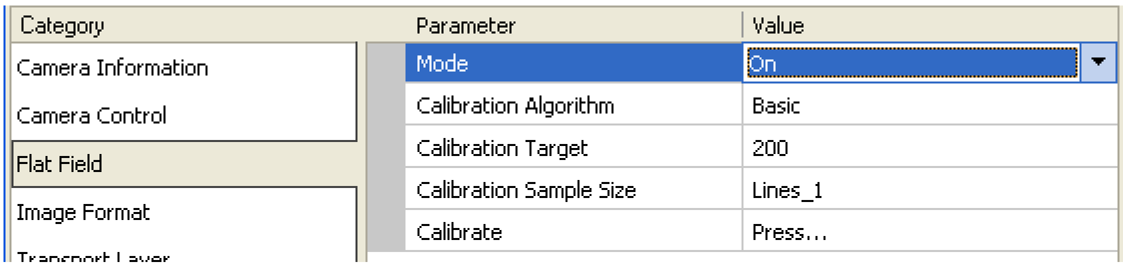


Figure 19: Flat Field Calibration in CamExpert

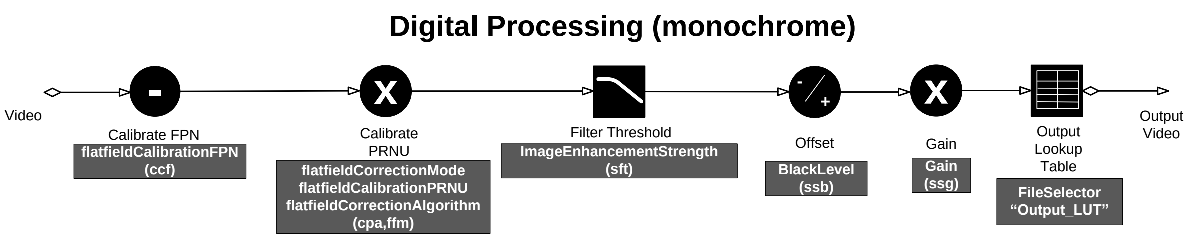


Figure 20: Camera Calibration Process.

1. Flat Field

This Flat Field set contains a number of features that are used to correct image distortion due to lens vignetting and uneven illumination. .

Note:
1. Flat field coefficients consist of an offset and gain for each pixel.
2. These are the first user corrections applied to the image.
3. The flat field coefficients are saved and loaded with the user set.

Parameter	**Description**
flatfieldCorrectionMode	1. Off – Flat field correction coefficients are not applied. 2. On – Flat field correction coefficients are applied. 3. Initialize – Sending this value will reset all current coefficients (offsets to 0 and gains to 1x).

flatfieldCorrectionAlgorithm	1. Basic – Direct calculation of coefficients based on current average line values and target. 2. LowPass – A low pass filter is first applied to the current average line values before calculating the coefficients. Use this algorithm if the calibration target is not uniform white or it s not possible to defocus the image. Because of the low pass filter this algorithm is not able to correct pixel-to-pixel variations and so it is preferable to use the "Basic" algorithm if possible.
flatfieldCalibrationTarget	1. After calibration all pixels will be scaled to output this level 2. Range depends on pixel format: • 8 bit: 0 to 255 DN • 10 bit: 0 to 1023 DN • 12 bit: 0 to 4095 DN
flatfieldCalibrationSampleSize	1. Number of lines to average when calibrating 2. 2048 or 4096
flatfieldCalibrationROIOffsetX	1. Together with "flatfieldCalibrationROIWidth" specifies the range of pixels to be calibrated. Pixel coefficients outside this range are not changed. It is possible to calibrate different regions sequentially.
flatfieldCalibrationROIWidth	
flatfieldCalibrationFPN	1. Save average line (of "flatfieldCalibrationSampleSize" rows). This is the first user correction applied – it is subtracted from each line. 2. This feature may not be of use to many users as the camera already subtracts true "dark current", but it may be useful for some to provide a per pixel offset correction. 3. Range 0 to 511 DN, 12 bit 4. Default value is 0 DN for each pixel
flatfieldCalibrationPRNU	1. Use "flatfieldCorrectionAlgorithm" to calculate the per pixel gain to achieve the specified target output. 2. Range 0 to 15.9998x 3. Default 1x

2. Contrast Enhancement

Two features to maximize the use of the output dynamic range (especially when pixel format is less than 12 bits). Typical use is to subtract minimum pixel value expected and then gain up maximum pixel value to approach full scale.

Offset

1. Single value added to each pixel
2. Range -512 to 511 DN, scaled down according to pixel format
3. Positive values may be used to measure dark noise

Gain

1. Floating point digital multiplier applied to each pixel
2. Range 1x to 10x

Appendix A: GenICam Commands

This appendix lists the available GenICam camera features. Access these features using the CamExpert interface.

DeviceInformation "Camera Information" Group

Name	**DeviceModelName**
Display Name	"Model"
Name Space	Standard
Visibility	Beginner
Access	Read-only
Type	String
Values	"P4_CM_08K070_00_R"
Name	**DeviceVendorName**
Display Name	"Vendor"
Name Space	Standard
Visibility	Beginner
Access	Read-only
Type	String
Values	"Teledyne DALSA"
Name	**DeviceID**
Display Name	"Serial Number"
Name Space	Standard
Visibility	Expert
Access	Read-only
Type	String
Values	e.g. "15005465"
Name	**DeviceFirmwareVersion**
Display Name	"Microcode Version"
Name Space	Standard
Visibility	Expert
Access	Read-only
Type	String
Values	e.g. "03-081-20235-03"

Name	**DeviceVersion**
Display Name	"CCI Version"
Name Space	Standard
Visibility	Expert
Access	Read-only
Type	String
Values	e.g. "03-110-20242-03"
Name	**DeviceManufacturerInfo**
Display Name	"FPGA Version"
Name Space	Standard
Visibility	Expert
Access	Read-only
Type	String
Values	e.g. "03-056-20378-04"
Name	**DeviceBISTStatus**
Display Name	"Power-on Status"
Name Space	Custom
Visibility	Beginner
Access	Read-only
Type	String
Values	"Good" I2C 1 FPGA_NO_INIT 10 FPGA_NO_DONE 100 EXT_SRAM 1000 ECHO_BACK 1,0000 FLASH_TIMEOUT 10,0000 FLASH_ERROR 100,0000 NO_FPGA_CODE 1000,0000 NO_COMMON_SETTINGS 1,0000,0000 NO_FACTORY_SETTINGS 10,0000,0000 NO_USER_SETTINGS 100,0000,0000 NO_FLAT_FIELD 1000,0000,0000 NO_ADC_COEFFICIENTS 1,0000,0000,0000 NO_FPN_MIN 10,0000,0000,0000 NO_FPN_MAX 100,0000,0000,0000 NO_PRNU_HI 1000,0000,0000,0000 NO_FEED 1,0000,0000,0000,0000 NO_LINEARITY 10,0000,0000,0000,0000 SYNC_ERROR 100,0000,0000,0000,0000 OVER_TEMPERATURE 1000,0000,0000,0000,0000 SPI 1,0000,0000,0000,0000,0000 NO_USER_FPN 10,0000,0000,0000,0000,0000 PLL_LOCK_FAILED 100,0000,0000,0000,0000,0000 INVALID_CCI 1000,0000,0000,0000,0000,0000 NO_LUT 1,0000,0000,0000,0000,0000,0000
Description	If the LED is green then this feature will return the string "Good". If the LED is red then it will a string of flags that indicate all the things that are wrong. More than one flag can be set. Most are for Teledyne DALSA to trouble shoot the camera. The ones that the user can do something about are: • NO_COMMON_SETTINGS, NO_USER_SETTINGS, NO_FLAT_FIELD, and NO_USER_FPN all indicate that the saved settings have been corrupted

	(possibly from the camera losing power while saving). The firmware will initialize the current values to defaults. The user should save these settings. Reset camera to clear error. • OVER_TEMPERATURE – Internal camera temperature has exceeded 75 C. There will be NO OUTPUT. The user should resolve why the camera is overheating (e.g. poor heat sink, no air movement) and then reset the camera.
Name	**DeviceLEDColorControl**
Display Name	"LED Colour"
Name Space	Custom
Visibility	Expert
Access	Read-only
Type	String
Values	"Green" – Ready "Light Blue" – Busy, powering up or running calibration command "Red" – Error, check BiST "Dark Blue" – In boot loader
Name	**DeviceTemperature**
Display Name	"Temperature"
Name Space	Standard
Visibility	Beginner
Access	Read-only
Type	Float
Units	Celsius
Values	0 to 75 C
Name	**InputVoltage**
Display Name	"Input Voltage"
Name Space	Standard
Visibility	Beginner
Access	Read-only
Type	Float
Units	Volts
Values	12 to 24 volts
Name	**UserSetDefaultSelector**
Display Name	"Power-on User Set"
Name Space	Standard
Visibility	Beginner
Access	Read-Write
Type	Enumeration
Values	"Factory" "UserSet1" to "UserSet8"
Description	This value specifies which user set will be loaded at power-on. This value is automatically saved when written.

Name	**UserSetSelector**
Display Name	"Current User Set”
Name Space	Standard
Visibility	Beginner
Access	Read-Write
Type	Enumeration
Values	"Factory" "UserSet1" to “UserSet8”
Description	Parameter for UserSetLoad and UserSetSave that specifies which user set to act on.
Name	**UserSetLoad**
Display Name	"Load User Set”
Name Space	Standard
Visibility	Beginner
Access	Write-only
Type	Command
Values	1
Description	Commands camera to load user set specified by UserSetSelector and make it current.
Name	**UserSetSave**
Display Name	"Save User Set”
Name Space	Standard
Visibility	Beginner
Access	Write -only
Type	Command
Values	1
Description	Commands camera to save current settings to user set specified by UserSetSelector. This feature is not available when UserSetSelector equals "Factory".
Name	**SecurityUpgrade**
Display Name	"License Key”
Name Space	Custom
Visibility	Guru
Access	Read-Write
Type	String
Description	A license key string will be sent by Teledyne DALSA if a feature upgrade is purchased.

deviceSensorControl “Camera Control” Group

Name	**TriggerMode**
Display Name	"Trigger Mode”
Name Space	Standard
Visibility	Beginner
Access	Read-Write
Type	Enumeration
Values	“Off” - Internal programmable line rate used, see AcquisitionLineRate “On” - Trigger provided on CC1

Name	**AcquisitionLineRate**
Display Name	"Internal Line Rate”
Name Space	Standard
Visibility	Beginner
Access	Read- Write
Type	Integer
Units	Hertz
Values	1 to 70,000
Description	Maximum line rate is limited by exposure time, Camera Link mode, and horizontal binning.
Name	**MeasureLineRate**
Display Name	“Measured Line Rate”
Name Space	Custom
Visibility	Beginner
Access	Read-only
Type	Integer
Units	Hertz
Values	Use to verify signal on CC1 when “TriggerMode” = “On”
Name	**ExposureMode**
Display Name	“Exposure Time Source”
Name Space	Standard
Visibility	Beginner
Access	Read- Write
Type	Enumeration
Values	“Timed” - Exposure time is set with ExposureTime “TriggerWidth” - Exposure time equals high time of CC1 signal.
Description	“TriggerWidth” is only available when TriggerMode equals “On”
Name	**ExposureTime**
Display Name	“Exposure Time”
Name Space	Standard
Visibility	Beginner
Access	Read-Write
Type	Float
Units	Micro-seconds
Values	11 to 300
Description	Maximum exposure time is limited by the line rate.
Name	**MeasureExposureTime**
Display Name	"Measured Exposure Time”
Name Space	Custom
Visibility	Beginner
Access	Read-only
Type	Integer
Units	Nano-seconds
Values	11,000 to 300,000

Name	**SensorTDIStagesSelection**
Display Name	"TDI Stages"
Name Space	Standard
Visibility	Beginner
Access	Read-Write
Type	Integer
Values	1 or 2
Name	**ScanDirectionSource**
Display Name	"Direction Source"
Name Space	Standard
Visibility	Beginner
Access	Read-Write
Type	Enumeration
Values	"Internal" - Scan direction controlled by SensorScanDirection "External" - Scan direction controlled by CC3
Description	CC3 low selects forward, high selects reverse
Name	**SensorScanDirection**
Display Name	"Internal Direction"
Name Space	Standard
Visibility	Beginner
Access	Read-Write
Type	Enumeration
Values	"Forward" "Reverse"
Description	The direction control features are only available when SensorTDIStagesSelection equals two. This feature controls which row is delayed before summing.
Name	**BlackLevel**
Display Name	"Offset"
Name Space	Standard
Visibility	Beginner
Access	Read-Write
Type	Integer
Units	DN
Values	-32 to 31 When PixelFormat equals "Mono8" -128 to 127 When PixelFormat equals "Mono10" -512 to 511 When PixelFormat equals "Mono12"
Name	**Gain**
Display Name	"Gain"
Name Space	Standard
Visibility	Beginner
Access	Read-Write
Type	Float
Units	Multiplier
Values	1 to 10

Name	**ClConfiguration**
Display Name	"Camera Link Configuration"
Name Space	Standard
Visibility	Beginner
Access	Read-Write
Type	Enumeration
Values	"Base" "Medium" "Full"

ImageFormatControl "Image Format" Group

Name	**TestImageSelector**
Display Name	"Test Pattern"
Name Space	Standard
Visibility	Beginner
Access	Read-Write
Type	Enumeration
Values	"Off" "Ramp" "A5" "Each_tap_fixed" "All_1365" "All_1"
Description	All processing (e.g. gain) is disabled when a test pattern is selected
Name	**BinningVertical**
Display Name	"Vertical Binning"
Name Space	Standard
Visibility	Beginner
Access	Read-Write
Type	Integer
Values	1 or 2
Description	SensorTDIStagesSelection must be equal to one to set this feature to two
Name	**BinningHorizontal**
Display Name	"Horizontal Binning"
Name Space	Standard
Visibility	Beginner
Access	Read-Write
Type	Integer
Values	1 or 2

Name	ReverseX
Display Name	"Line Mirroring”
Name Space	Standard
Visibility	Beginner
Access	Read-Write
Type	Enumeration
Values	“Off” - “On” - Pixel order is reversed
Name	**PixelFormat**
Display Name	"Pixel Format”
Name Space	Standard
Visibility	Beginner
Access	Read-Write
Type	Enumeration
Values	“Mono8” “Mono10” “Mono12”

FileAccessControl “File Access Control” Group

All features from the GenICam Standard Features Naming Convention have been implemented.

Name	FileSelector
Display Name	"File Selector”
Name Space	Standard
Visibility	Expert
Access	Read-Write
Type	Enumeration
Values	“User_Set” - Use UserSetSelector to specify which user set to access "User_FPN" - Use UserSetSelector to specify which user FPN to access "Flat_Field" - Use UserSetSelector to specify which user flat field to access "Output_LUT" - Use UserSetSelector to specify which user output LUT to access "FPGA_Code" - Used for firmware upgrades "Microcode" - Used for firmware upgrades "CCI" - Used for firmware upgrades "XML" - Used for firmware upgrades

serialPortControl "Serial Port" Group

Name	**DeviceSerialPortBaudRate**
Display Name	"Baud Rate"
Name Space	Standard
Visibility	Expert
Access	Read-Write
Type	Enumeration
Values	"Baud_9600" (factory default) "Baud_19200" "Baud_57600" "Baud_115200" "Baud_230400"* "Baud_460800"* "Baud_921600"* Note: During connection CamExpert automatically sets the camera to maximum allowable baud. *Your system requires a Px8 frame grabber to achieve these baud rates.

dataProcessing "Flat Field" Group

This group contains a number of features to correct image distortion due to lens vignetting and uneven illumination:

1. Flat field coefficients consist of an offset and gain for each pixel
2. These are the first user corrections applied to the image
3. The flat field coefficients are saved and loaded with the user set

Name	**flatfieldCorrectionMode**
Display Name	"Mode"
Name Space	Custom
Visibility	Beginner
Access	Read-Write
Type	Enumeration
Values	"Off" - FPN and flat field coefficients disabled "On" - FPN and flat field coefficients enabled "Initialize" - Reset all FPN to 0 and all flat field coefficients to 1
Name	**flatfieldCorrectionAlgorithm**
Display Name	"Calibration Algorithm"
Name Space	Custom
Visibility	Expert
Access	Read-Write
Type	Enumeration
Values	"Basic" Direct calculation of coefficients based on average line values and target "LowPass" A low pass filter is first applied to the average line values before calculating the coefficients. Use this algorithm if the calibration target is not uniformly white or it is not possible to defocus the image. Because of the low pass filter this algorithm is not able to correct pixel-to-pixel variations and so it is preferable to use the "Basic" algorithm if possible.

Name	**flatfieldCalibrationTarget**
Display Name	"Calibration Target"
Name Space	Custom
Visibility	Beginner
Access	Read-Write
Type	Integer
Values	0 to 255 When PixelFormat equals "Mono8" 0 to 1023 When PixelFormat equals "Mono10" 0 to 4095 When PixelFormat equals "Mono12"
Name	**flatfieldCalibrationSampleSize**
Display Name	"Calibration Sample Size
Name Space	Custom
Visibility	Expert
Access	Read-Write
Type	Enumeration
Values	"Lines_2048" "Lines_4096"
Name	**flatfieldCalibrationROIOffsetX**
Display Name	"ROI Offset X"
Name Space	Custom
Visibility	Expert
Access	Read-Write
Type	Integer
Values	1 to 8192
Description	Together with flatfieldCalibrationROIWidth specifies the pixels that will be calibrate. Pixel coefficients outside this region are not changed. Range is limited by flatfieldCalibrationROIWidth. It is possible to calibrate different regions sequentially.
Name	**flatfieldCalibrationROIWidth**
Display Name	"ROI Width"
Name Space	Custom
Visibility	Expert
Access	Read-Write
Type	Integer
Values	1 to 8192
Description	Together with flatfieldCalibrationROIOffsetX specifies the pixels that will be calibrate. Pixel coefficients outside this region are not changed. Range is limited by flatfieldCalibrationROIOffsetX.

Name	**flatfieldCalibrationFPN**
Display Name	"Calibrate FPN"
Name Space	Custom
Visibility	Expert
Access	Write-only
Type	Command
Values	1
Description	Save average line (of "flatfieldCalibrationSampleSize" rows). This is the first user correction applied – it is subtracted from each line. This feature may not be of use to many users as the camera already subtracts true "dark current", but it may be useful for some to provide a per pixel offset correction. Range of FPN values is 0 to 511 DN, 12 bit

Name	**flatfieldCalibrationPRNU**
Display Name	"Calibrate PRNU"
Name Space	Custom
Visibility	Beginner
Access	Write-only
Type	Command
Values	1
Description	Use "flatfieldCorrectionAlgorithm" to calculate the per pixel gain to achieve the specified target output. Range 0 to 15.9998x

Name	**ImageEnhancementStrength**
Display Name	"Filter Threshold"
Name Space	Custom
Visibility	Guru
Access	Read-Write
Type	Integer
Values	0 to 16, 0 disables the filter

Description	The image enhancement filter seeks to improve the visual appearance of an image and to represent the image to a form better suited for machine analysis. The image enhancement filter is applied between flat-field and offset. The filter algorithm is:
	
	for each pixel P_i where $1 < i < 8092$ do
	    if TDI stages = 1 and vertical binning = 1 then
	        if abs($P_i – P_{i-1}$) + abs($P_{i+1} – P_i$) $<$ ImageEnhancementStrength / 2 then
	            $P_i = 0.125 \times P_{i-1} + 0.75 \times P_i + 0.125 \times P_{i+1}$
	        end if
	    else
	        if abs($P_i – P_{i-1}$) + abs($P_{i+1} – P_i$) $<$ ImageEnhancementStrength then
	            $P_i = 0.25 \times P_{i-1} + 0.5 \times P_i + 0.25 \times P_{i+1}$
	        end if
	    end if
	next pixel

TransportLayerControl “Transport Layer” Group

Name	**DeviceReset**
Display Name	"Restart Camera”
Name Space	Standard
Visibility	Expert
Access	Write-only
Type	Command
Values	1
Name	**DeviceManifestXMLMajorVersion**
Display Name	"XML Major Version”
Name Space	Standard
Visibility	Expert
Access	Read-only
Type	Integer
Description	Together with DeviceManifestXMLMinorVersion specifies the GenICam feature description XML file version
Name	**DeviceManifestXMLMinorVersion**
Display Name	"XML Minor Version”
Name Space	Standard
Visibility	Expert
Access	Read-only
Type	Integer
Description	Together with DeviceManifestXMLMajorVersion specifies the GenICam feature description XML file version

Name	GenCPStatus
Display Name	"Last GenCP Status"
Name Space	Custom
Visibility	Expert
Access	Read-only
Type	Integer
Values	1. GenCP standard errors: SUCCESS 0x0000 NOT_IMPLEMENTED 0x8001 INVALID_PARAMETER 0x8002 INVALID_ADDRESS 0x8003 WRITE_PROTECT 0x8004 BAD_ALIGNMENT 0x8005 ACCESS_DENIED 0x8006 BUSY 0x8007 LOCAL_PROBLEM 0x8008 MISMATCH 0x8009 INVALID_PROTOCOL 0x800A MSG_TIMEOUT 0x800B WRONG_CONFIG 0x800F INVALID_HEADER 0x8010 GENERIC_ERROR 0x8FFF 2. Teledyne DALSA P4 specific errors: I2C 0xC001 FPGA_NO_CODE 0xC002 FPGA_NO_INIT 0xC003 FPGA_NO_DONE 0xC004 NO_COMMON_SETTINGS 0xC005 FLASH_TIMEOUT 0xC006 FLASH_ERROR 0xC007 SET_NOT_SAVED 0xC008 NO_FACTORY_SETTINGS 0xC009 NO_USER_SETTINGS 0xC00A NO_FLAT_FIELD 0xC00B EXT_SRAM 0xC00C FPGA_ID 0xC00D ECHO_BACK 0xC00E FILE_TOO_BIG 0xC00F NO_ADC_COEFFICIENTS 0xC010 NO_FPN_LO 0xC011 NO_FPN_HI 0xC012 NO_PRNU 0xC013 INVALID_FILE 0xC014 FILE_NOT_OPEN 0xC015 NO_XML 0xC016 NO_FEED_THROUGH 0xC017 NO_LINEARITY 0xC018 SYNC_ERROR 0xC019 OVER_TEMPERATURE 0xC01A GET_LINE_TIMEOUT 0xC01B CPA_TOO_MANY_OUTLIERS 0xC01C NO_USER_FPN 0xC01D USER_FPN_CLIPPING 0x401E FLAT_FIELD_CLIPPING 0x401F PLL_LOCK_FAILED 0xC020

	INVALID_CCI 0xC021 NO_LUT 0xC022
Description	1. If a feature read or write fails then Sapera only returns that it fails – read this feature to get the actual reason for the failure 2. Returns the last error 3. Reading this feature clears it 4. Description of most common a. SUCCESS Command executed as expected b. INVALID_PARAMETER Most likely out of range. Sometimes range changes depending on other features. For example, exposure time must fit with line rate. c. INVALID_ADDRESS Register (feature) not implemented in camera d. INVALID_FILE Likely trying to upload the wrong file – e.g. uploading XML file after selecting microcode e. OVER_TEMPERATURE Internal camera exceeds 75 C. Camera shuts down a number of the hot components and so there is no video output. Must resolve why the camera has over heated (e.g. poor heat sink or air flow) and then reset camera to re-enable output. f. GET_LINE_TIMEOUT Attempting user FPN or flat field calibration in external trigger mode without providing an EXSYNC g. CPA_TOO_MANY_OUTLIERS Flat field calibration using low-pass filter algorithm failed because image is not sufficiently uniform h. USER_FPN_CLIPPING Warning (command still executed) – During calibration some of the user FPN coefficients were clipped to the maximum 511 DN (12 bit) – redo with less light, or shortened exposure time i. FLAT_FIELD_CLIPPING Warning (command still executed) – During calibration some of the user flat field coefficients were clipped to the maximum 16x – redo with an initially flatter image

Appendix B: ASCII Commands

The following commands can be used to control the Teledyne DALSA Piranha4 P4-CM-08K070-00-R camera.

To access the TLC an ASCII-based communications tool, such as Hyperterminal or equivalent, must be used.

First, cycle power to the camera either by issuing the reset camera (rc) command or by powering the camera OFF and then ON. Next, load the ASCII interface. Finally, press the <ESC> key. (Note that while the camera is initializing the <ESC> command is ignored.) A list of the available commands will display.

To switch from the ASCII-command interface to the GenCP interface, the camera must be either reset or go through the power cycle.

Note that the HyperTerminal application is not available on the Windows 7 OS.

Alternatives to HyperTerminal
The following alternative ASCII-interfaces have been tested and shown to work with this camera: PuTTY and TeraTerm. Note that PuTTY does not have Xmodem capability while TeraTerm does. Xmoden is required to update code in the camera.

TeraTerm http://logmett.com/index.php?/download/tera-term-473-freeware.html
PuTTY http://putty.en.softonic.com/

The camera responds to a simple ASCII-based protocol. A carriage return <CR> ends each command.

Example: to return the current detector settings
gcp <CR>

A complete list of the available detector commands, their format and parameters can be displayed by sending the help (**h**) command.

CCF – Calibrate User FPN

The value selected is the number of lines to average. For more information, refer to the GenICam feature **flatfieldCalibrationFPN**.

```
ccf <2048 | 4096>
```

CLM – Camera Link Mode

```
CLM <mode>
```

Set Camera Link mode

CLM	Name	Taps	SPF*	Cables
1	Base	2	8, 10, 12	1
2	Medium	4	8, 10, 12	2
3	Full	8	8	2

*- Set Pixel Format (number of bits per pixel)

CPA – Flat Field Calibration

```
CPA <algorithm> <# lines> <target>

<algorithm> 0: Basic or 1: Filter
<# lines>   2048 or 4096
<target>    Integer
            0 to 4095 DN in 12 bit mode
            0 to 1023 DN in 10 bit mode
            0 to 255 DN in 8 bit mode
```

- Perform flat field calibration using the average of <# lines>.
- With filter algorithm this average line is then smoothed and outlier pixels are interpolated.
- Use this feature if your white reference is not featureless.
- Adjust pixel gain such that output will be <target>.
- The target is first divided by horizontal binning factor and gain and then the offset is subtracted. Therefore the output will go to the target.
- Because the PRNU can be less than 1, the target may be below the current maximum value.
- Flat field coefficients are save as part of the user set - see USS command.

FCS – Upload Files

```
FCS <#>
```

Upload files to camera using HyperTerminal Xmodem protocol.

```
1. User Set
2. Flat Field Coefficients
3. LUT
4. FPGA
5. Microcode
6. CCI
```

```
7. User XML
```

Sequence is:

1. Enter “FCS <#>” command from HyperTerminal
2. Click on “Transfer”
3. Browse and find file
4. Select “Xmodem” protocol
5. Click “Send”
6. When it indicates that it is done click “Close”

- Files are not used until the camera is rebooted.

FFM – Flat Field Mode

```
FFM <mode>

0. Disable flat field correction coefficients
1. Enable flat field correction coefficients
```

GCP – Get Camera Parameters

```
GCP
```

Displays current camera configuration parameters. For example:

```
USER>gcp
Model       P4_CM_08K070_00_R
Microcode   03-081-20235-03
CCI         03-110-20242-03
FPGA        03-056-20378-04
Serial #    15005465
BiST:       Good

DefaultSet 1
Ext Trig    Off
Line Rate   10000 [Hz]
Meas L.R.   10000 [Hz]
Max  L.R.   19417 [Hz]
Exp. Mode   Timed
Exp. Time   50000 [ns]
Meas E.T.   49993 [ns]
Max  E.T.   98500 [ns]

Test Pat.   0:Off
Direction   Internal, Forward
TDI Stages 2
Vert. Bin   1
Flat Field On
Filter      0
Offset      0
Gain        1.00
Hor. Bin    1
Mirror      Off
CL Config   Full
```

```
Pixel Fmt  8 bits
CPA ROI    1-8192
USER>
```

H – Help

```
H
```

Display “help”, an alphabetical list of all commands.
Also shows the microcode build time stamp. For example:

```
USER>h
P4 (03-081-20235-02): Command Line Interpreter Mar  7 2012, 10:45:18

ccf  - Calibrate User FPN <2048|4096>
clm  - Camera Link Mode <0:Base 1:Med 2:Full>
cpa  - Calibrate Flatfield <0:basic 1:filter><2048|4096><DN target>
ffm  - Flat Field Mode <0:Off 1:On>
gcp  - Display Camera Configuration
h    - Help
rc   - Reset Camera
roi  - Set Flatfield ROI <1st pixel> <last pixel>
rpc  - Reset Flatfield Coefficients
sbh  - Horizontal Binning <1|2>
sbr  - Set Baud Rate <9600|57600|115200|230400|460800|921600>
sbv  - Vertical Binning <1|2>
scd  - Direction <0:Fwd, 1:Rev 2:Ext>
sem  - Exposure Mode <0:Int 1:Ext>
set  - Exposure Time <ns>
sft  - Set Filter Threshold <DN>
smm  - Mirroring <0:Off 1:On>
spf  - Pixel Format <0:8 1:10 2:12 bits>
ssb  - Offset <DN>
ssf  - Internal Line Rate <Hz>
ssg  - Gain f<gain>
stg  - TDI Stages <1|2>
stm  - External Trigger <0:Off 1:On>
svm  - Test Pattern <0,1,3-6>
usd  - Default User Set <0-8>
usl  - Load User Set <0-8>
uss  - Save User Set <1-8>
vt   - Temperature <0>
vv   - Input Voltage
USER>
```

RC – Reset Camera

```
RC
```

The micro-controller reboots:

- Load any file updates
- Clear over temperature condition
- Perform start up camera tests (BiST)

- Load FPGA code
- Configure FPGA and sensor.
- Load default user set
- Baud rate set to 9600

ROI – Set Flatfield ROI

```
roi <1st pixel> <last pixel>
```

RPC – Reset Flatfield Coefficients

```
rpc
```

SBH – Set Binning Horizontal

```
SBH <#>
1.default
2.
```

SBR – Set Baud Rate

```
SBR <#>
```

- Set communication speed with the host terminal.
- After typing this command and pressing "Enter", change the speed of the terminal program to match.
- Valid baud rates for most frame grabbers are: {9600, 57600, 115200, 230400*, 460800*, 921600*} *PX8 frame grabber required.
- The factory default baud rate is 9600.

SBV – Set Binning Vertical

```
SBV <#>
1.Single line output.
2.Tall pixel mode.
```

- TDI Stage Selection (stg 1)
- In low sensitivity mode, the camera must be in internal direction control.

SCD – Set Direction

```
SCD <#>
```

- Set the direction that the image moves past the pair of sensor rows.
- That is, the way that the FPGA delays and then sums the sensor rows.
- Useful if the camera is mounted upside down.

```
0. Forward
1. Reverse (Not available in low sensitivity mode)
2. External (Not available in low sensitivity mode)
```

SEM – Set Exposure Mode

```
SEM <mode>
```

Set exposure mode:

```
0. Internal (“Timed”) exposure time
1. External (“PulseWidth”) exposure time
      a. Available only when STM = 1 (external trigger on)
      b. Exposure occurs when signal on CC1 is high
      c. When CC1 signal falls line is read
```

SET – Set Exposure Time

```
SET <ns>
```

Set internal exposure time in nanoseconds – 25 ns resolution.

```
<ns>  Exposure time in nanoseconds
      Integer: 11,000 to 3,000,000 ns
```

Special Note: Line time > (Exposure time + 1,500 ns) will return error 0xC002 (GenCP “Invalid Parameter”) if this condition is not met. You must adjust these two parameters in the correct sequence to maintain this condition.

SFT – Set Filter Threshold

```
sft <DN>
```

The image enhancement filter seeks to improve the visual appearance of an image and to represent the image to a form better suited for machine analysis. It improves signal to noise ratio by applying an adaptive FIR filter in spatial domain based on local contrast analysis.

```
<DN>  Range 0 to 16 for dual-line mode, default 5.
      Range 0 to 8 for single-line mode, default 2.
```

Note: The *smaller* the number, the lower the filters effect.

SMM – Set Mirror Mode

```
smm <#>
0. Off
1. On
```

SPF – Set Pixel Format

```
spf <#>
0. 8 bits
1. 10 bits
2. 12 bits (only available with Base or Medium Camera Link configurations)
```

SSB – Set Offset

```
SSB <offset>
```

Set contrast offset – single value added to all pixels after PRNU/ flat field coefficients (before gain).

```
<offset>   Signed integer: -512 to 511 (dependent on gain and bit mode)
```

SSF – Set Line Rate

SSF <line rate>

Set internal line rate in Hertz.

<line rate> Internal line rate in Hertz.
Integer: 1 to 70,000 Hz

Special Note: Line time > (Exposure time + 1,500 ns) will return error 0xC002 (GenCP “Invalid Parameter”) if this condition is not met. You must adjust these two parameters in the correct sequence to maintain this condition.

SSG – Set Gain

SSG f<gain>

Set gain – single value multiplied by all pixels.

Final correction.

<gain> Floating point number: 1.0 to 10.0. Note that gain value must be preceded by an “f”.

STG – Set TDI Stages

STG <number>

Set TDI stages:

1. Single line, low sensitivity mode. In low sensitivity mode the camera must be internal direction control.
2. Pair of lines summed with suitable delay, high sensitivity mode.

Note: STG 2 will supersede SBV 2.

STM – Set Trigger Mode

SEM <mode>

Set exposure mode:

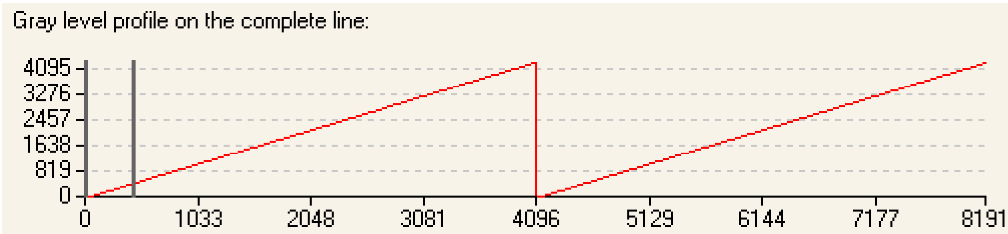
1. Internal (“Timed”) exposure time
2. External (“PulseWidth”) exposure time
    a. Available only when STM = 1 (external trigger on)
    b. Exposure time equals high time of EXSYNC on signal on CC1

SVM – Select Test Pattern

SVM <pattern>

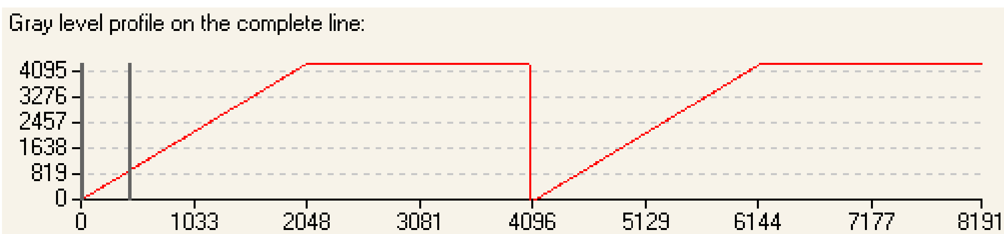
Select sensor video or FPGA generated test pattern:

1. Sensor video
2. Ramp – (good for when STG or SBV is 2)



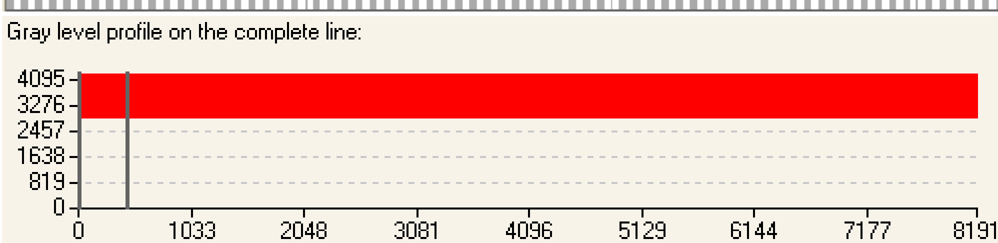

```
Pixels: { 1, 2, 3,… 4096, 4097, 4098, 4099,…8192 }
Values: { 0, 1, 2,… 4095,    0,    1,    2,…4095 }
```

3. Ramp - 24 to 4095, 0 to 4095, in low sensitivity mode



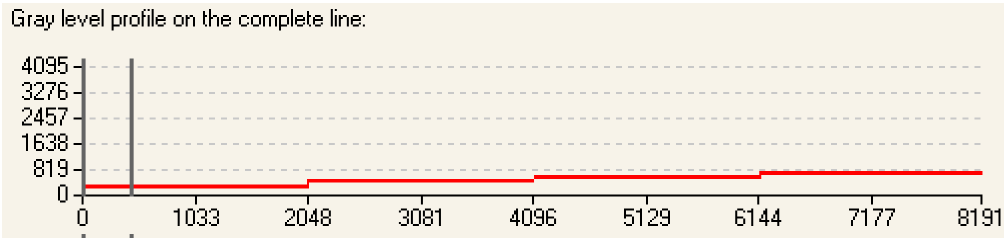

```
Pixels: { 1,   2,   3,…2024; 2025…4072; 4073, 4074, 4075,…6144; 6145…8192 }
Values: { 48, 50, 52,…4094;       4095;    0,    2,    4,…4094;      4095 }
```

4. Four pixels repeating



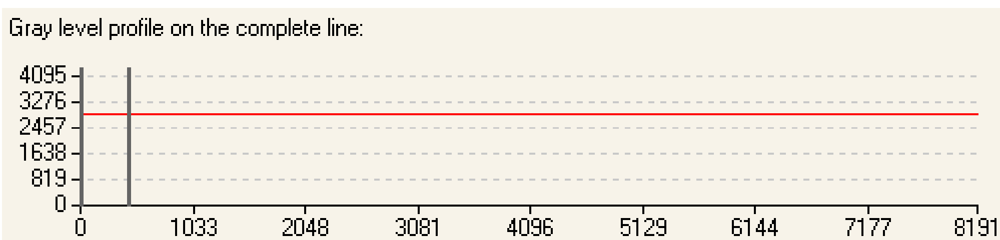

```
Pixels: {    1,    2,    3,    4,    5,    6,    7,    8,    9,… }
Values: { 2730, 2730, 2730, 2730, 4095, 4095, 4095, 4095, 2730,… }
```

5. Fixed value per tap



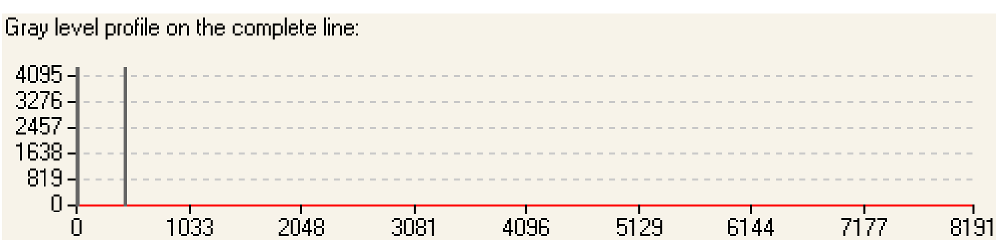

```
Pixels (1-2036):    {    1,    2,    3,    4,    5,    6,    7,    8,… }
Values:             {  288,  320,  352,  384,  288,  320,  352,  384,… }
Pixels (2037-4096): {2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044,… }
Values:             {  416,  448,  480,  512,  416,  448,  480,  512,… }
Pixels (4097-6157): {4097, 4098, 4099, 4100, 4101, 4102, 4103, 4104,… }
Values:             {  544,  576,  608,  640,  544,  576,  608,  640,… }
Pixels (6158-8192): {6158, 6159, 6160, 6161, 6162, 6163, 6164, 6165,… }
Values:             {  672,  704,  736,  768,  672,  704,  736,  768,… }
```

6. Fixed: 1365




```
Pixels: {    1,    2,    3,… }
Values: { 2730, 2730, 2730,… }
```

7. Fixed: 1




```
Pixels: { 1, 2, 3,… }
Values: { 1, 1, 1,… }
```

VT – Read Temperature

```
TMP <channel>
```

Read temperature and display in degrees Celsius (one decimal place).

```
1. Internal camera temperature
```

USD – User Set Default

```
USD <set#>
```

Set User Set Default, that is, the user set that will be loaded on power up. Value is written to the user flash.

```
<set#>      0 – Factory set, 1 to 8 – User sets
```

USL – User Set Load

```
USL <set#>
```

Load a previously saved User Set.
Includes features on GCP screen and flat field coefficients.

```
<set#>      0 – Factory set, 1 to 8 – User sets
```

USS – User Set Save

```
USS <set#>
```

Save a User Set to data flash. Includes features in GCP screen and flat field coefficients.

```
<set#>
1 to 8 – User sets, saved to the user flash
```

VV – Read Voltage

```
VV
```

Read and display input voltage – should between 12 and 24 volts for proper camera operation.

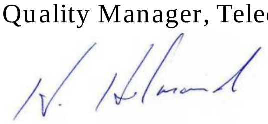
EMC Declaration

The CE Mark Evaluation of the Teledyne DALSA P4-CM-08K070-00-R Cameras, which are manufactured by Teledyne DALSA Inc., meets the following requirements:

Standard	Test Description
EN 55011, FCC Part 15, CISPR 11, and ICES-003	Radiated emissions requirements.
EN 61326-1 and EN55024	Immunity to disturbances.

Changes or modifications not expressly approved by Teledyne DALSA could void the user's authority to operate the equipment.

Name and Signature of authorized person
Hank Helmond
Quality Manager, Teledyne DALSA Corp.



Dated: December 22, 2011

Revision History

Revision Number	Change Description	Revision Date
00	Initial release.	16-Mar-12
01	-Revised list of GenICam commands added. -Calibration process diagram added. -Revised responsivity graph added.	27-June-12

Index

A

antiblooming, 9

B

baud rate, 35
binning, 38
black level
  control, 35

C

calibration, 39
  flat field, 39
  process chain, 39
camera control signals, 18
camera information, 26
camera interfacing tool, 22
Camera Link
  cables, 18
  configurations, 29
  input signals, 18
  outputs, 19
Camera Link connector, 15
CamExpert, 23
certifications, 9
cleaning
  sensor window, 6
clock signals, 19
commands
  ASCII, 55
  GenICam, 41
compliance, 9
connectors, 14
  Camera Link, 15
  power, 19

D

data bus, 19
DC offset, 9
direction
  sensor shift, 37
  web movement, 37
direction control, 36

E

EMC Declaration of Conformity, 65
exposure
  control, 31
  external frame rate, programmable exposure time, 32
  externally controlled, 32
  internally controlled, 32
exposure modes
  descriptions of, 31
exposure time
  set, 34
EXSYNC, 18

F

factory settings, 26

G

Gain
  control, 35
grounding instructions, 15
GUI
  CamExpert, 23
  overview, 21

I

image acquisition, 31
input/ output, 14
interface
  mechanical, 8

L

LED
  definitions, 20

M

mechanical
  camera, 11
  specifications, 8
models, 8

O

operating
  ranges, 9

P

performance specifications, 8
pixel format, 36
power
  connector, 19
  connectors, 19
  guidelines, 19
  pinout, 19
precautions, 5

Q

quantum efficiency
  graph, 10

R

random noise, 9
rebooting, 38
requirements
  PC, 13
responsivity, 9
  graph, 10
revision history, 66

S

safety, 5
Sapera, 22
settings
  current, 28
  default, 29
  factory, 26, 29
  loading, 27
  saving, 27
  user, 28
setup
  overview, 13
shift direction, 37
size
  image, 35
software
  required, 8
specifications
  mechanical, 8
  operating, 9
  performance, 8

T

TDI Stages, 29
temperature
  verify, 27
test patterns, 25
trigger modes, 31

V

voltage
  verify, 27